TUGGERAH LAKES SECONDARY COLLEGE

THE ENTRANCE CAMPUS

HSC

CHEMISTRY

STUDENT HANDBOOK

Table of Contents

Higher School Certificate

Course Descriptions

Course: Chemistry	**Course No:** 15050
2 units for each of Preliminary and HSC Board Developed Course	**Exclusions:** Senior Science (Preliminary only)

Course Description

Chemistry is the study of the physical and chemical properties of matter, with a focus on substances and their interactions. Chemistry attempts to provide chemical explanations and to predict events at the atomic and molecular level.

The Preliminary course develops a knowledge of atomic structure, chemical changes, rates of reaction and relationships between substances by focusing on increasing students' understanding of the Earth's resources, the development of increasingly sophisticated methods to extract and use metals, the importance of water on Earth and high energy carbon compounds.

The HSC course builds on the concepts developed in the Preliminary course, expanding on areas such as the search for new sources of traditional materials, the design and production of new materials, the management and monitoring of chemicals that have been developed and/or released as a result of human technological activity and the way in which environmental problems could be reversed or minimised. The options cover a variety of interest areas and draw on the increased information and understanding provided by improved technology to examine areas of current research.

Topics Covered

Preliminary Course

Chemistry Skills Module 8.1

Core Modules

- The Chemical Earth
- Metals
- Water
- Energy

HSC Course

Chemistry Skills Module 9.1

Core Modules

- Production of Materials
- The Acidic Environment
- Chemical Monitoring and Management

One Option from the following modules:

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

Particular Course Requirements

Each module specifies content which provides opportunities for students to achieve the Chemistry skill outcomes. Chemistry modules 8.1 (Preliminary) and 9.1 (HSC) provide the skills content that must be addressed within and across each course. Teachers should provide opportunities based on the module content to develop the full range of skills content identified in Chemistry skills modules 8.1 and 9.1.

Students will complete a minimum of 80 indicative hours of practical experiences across Preliminary and HSC course time with no less than 35 hours in the HSC course. Practical experiences must include at least one open-ended investigation in both the Preliminary and HSC Courses.

Chemistry – Performance Band descriptions

The typical examination performance in this band:

Band 6

- demonstrates an extensive knowledge and understanding of the concepts of the chemistry course content including context, prescribed focus areas and domain
- displays an outstanding ability to describe and explain chemistry concepts, including abstract ideas, clearly and accurately, and to apply the concepts to unfamiliar situations
- applies a high level of critical thinking skills in developing appropriate solutions to problems involving a long sequence of related tasks
- analyses, evaluates and extrapolates chemical data effectively, identifies complex relationships, quantifies explanations and descriptions, and synthesizes information to draw conclusions
- communicates succinctly, logically and sequentially using a variety of scientific formats
- demonstrates a high level ability to design an experimental procedure

Band 5

- demonstrates a thorough knowledge and understanding of the concepts of the chemistry course content including context, prescribed focus areas and domain
- effectively communicates a detailed understanding of chemistry concepts using appropriate chemistry terminology and scientific formats, and applies the concepts to unfamiliar situations
- analyses information given in written, tabular, graphical and diagrammatic forms and relates this to other relevant information
- displays competence in manipulating equations to solve problems involving a number of steps
- demonstrates a thorough knowledge of the use of appropriate experimental procedures

Band 4

- demonstrates a sound knowledge and understanding of the concepts of the chemistry course content including context, prescribed focus areas and domain
- describes concepts and information clearly in written, graphical and diagrammatic forms such as structural and electron-dot formulae, and applies these concepts in familiar situations
- demonstrates a broad ability to carry out calculations and or substitute into equations, to use relevant symbols and units when manipulating chemical data including stoichiometric data, and to construct balanced chemical equations
- displays proficiency in selecting relevant data from information given in written, tabular, graphical and diagrammatic form
- describes correct apparatus for a particular chemical measurement and has an adequate understanding of experimental methodology.

Band 3

- demonstrates a basic knowledge and understanding of the concepts of the chemistry course content including context, prescribed focus areas and domain
- uses simple chemistry definitions, terms, diagrams and graphs to communicate understanding of chemistry concepts
- substitutes data from information given in written, tabular, graphical and diagrammatic form, and manipulates basic chemical data including stoichiometric data

Band 2

- demonstrates a limited knowledge and understanding of the chemistry course content including context, prescribed focus areas and domain
- recalls elementary terminology and formulae related to some areas of chemistry
- makes simple substitutions of data in chemical calculations
- describes simple safety precautions in experimental procedure

Band 1

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, the periodic table and bonding	P6 explains trends and relationships between elements in terms of atomic structure, the periodic table 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

CHEMISTRY TOPIC PLAN

Chemistry 2017-2018

For us to finish the course effectively, we need to follow this plan.

Term 4 2017			
Week	Date	Topic	Assessment
1			
2			
3			
4	30th Oct – 3rd Nov	Production of Materials	
5	6th - 10th Nov	Production of Materials	
6	13th - 17th Nov	Production of Materials	
7	20th – 24th Nov	Production of Materials	
8	27th Nov - 1st Dec	Production of Materials	
9	4th – 8th Dec	Production of Materials	Research/Oral Presentation
10	11th - 15th Dec	Production of Materials	
Term 1 2018			
Week	Date	Topic	Assessment
1	29th Jan – 2nd Feb	Production of Materials	
2	5th - 9th Feb	The Acidic Environment	
3	12th - 16th Feb	The Acidic Environment	
4	19th – 23rd Feb	The Acidic Environment	
5	26th Feb - 2nd Mar	The Acidic Environment	
6	5th - 9th Mar	The Acidic Environment	
7	12th - 16th Mar	The Acidic Environment	
8	19th – 23rd Mar	The Acidic Environment	
9	27th - 31st Mar	The Acidic Environment	
10	2nd – 6th Apr		Mid Course Exams
11	9th – 13th Apr		
Term 2 2018			
Week	Date	Topic	Assessment
1	1st – 4th May	Chem Monitoring & Manage	
2	7th - 11th May	Chem Monitoring & Manage	
3	14th - 18th May	Chem Monitoring & Manage	
4	21st - 25th May	Chem Monitoring & Manage	
5	28th May – 1st Jun	Chem Monitoring & Manage	
6	4th - 8th Jun	Chem Monitoring & Manage	
7	11th - 15th Jun	Chem Monitoring & Manage	
8	18th - 22nd Jun	Chem Monitoring & Manage	Practical and 2nd-hand data
9	25th – 29th Jun	Industrial Chemistry	
10	2nd – 6th Jul	Industrial Chemistry	
Term 3 2018			
Week	Date	Topic	Assessment
1	24th - 27th Jul	Industrial Chemistry	
2	30th Jul – 3rd Aug	Industrial Chemistry	
3	6th - 10th Aug	Industrial Chemistry	
4	13th - 17th Aug	Industrial Chemistry	
5	20th – 24th Aug		Trial HSC
6	27th - 31st Aug		
7	3rd - 7th Sep	Industrial Chemistry	
8	10th - 14th Sep	Industrial Chemistry	
9	17th – 21st Sep	Revision	
10	24th – 28th Sep	Revision	

SUBJECT: CHEMISTRY

TASK	WHEN	TOPIC/S	TYPE OF TASK	OUTCOMES	VALUE
1	Term 4, 2016 Week 9	Production of Materials	Research Oral Presentation	H12, H13, H14	25%
2	Term 1, 2017 Weeks 10-11	Production of Materials Acidic Environment	Mid Course Exam	H1 – H10	15%
3	Term 2, 2017 Week 8	Chem. Monitoring and Management	Practical and 2nd hand data Task	H11, H12, H13, H14	20%
4	Ongoing	Production of Materials Acidic Environment	First-Hand Investigation Reports	H11,H12,H13,H14	15%
5	Term 3, 2017 Weeks 5-6	ALL	Trial HSC	H1-10	25%

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.

HSC Course Outcomes	Content
A student: H11. justifies the appropriateness of a particular investigation plan	*Students:* 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
H15. explains why an investigation is best undertaken individually or by a team	The HSC course builds on the Preliminary course and further increases the students' skills in working individually and in teams.

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.

	Students learn to:	*Students:*
1. Fossil fuels provide both energy and raw materials such as ethylene, for the production of other substances	• 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	• 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

	Students learn to:	*Students:*
4. Oxidation-reduction reactions are increasingly important as a source of energy	• 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	• 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 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 • identify factors that affect the concentrations of a range of ions in solution in natural bodies of water such as rivers and oceans • 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	• perform first-hand investigations to use qualitative and quantitative tests to analyse and compare the quality of water samples • 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 • 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, plan and perform a first-hand investigation to identify the products of the electrolysis of an aqueous solution 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

A Glossary of Key Words for HSC Syllabuses

Account	Account for: state reasons for, report on. Give an account of: narrate a series of events or transactions
Analyse	Identify components and the relationship between them; draw out and relate implications
Apply	Use, utilise, employ in a particular situation
Appreciate	Make a judgement about the value of
Assess	Make a judgement of value, quality, outcomes, results or size
Calculate	Ascertain/ determine from given facts, figures or information
Clarify	Make clear or plain
Classify	Arrange or include in classes/ categories
Compare	Show how things are similar or different
Construct	Make; build; put together item or arguments
Contrast	Show how things are different or opposite
Critically (analysis/ evaluation)	Add a degree or level of accuracy depth, knowledge and understanding, logic, questioning, reflection and quality to (analysis/evaluation)
Deduce	Draw conclusions
Define	State meaning and identify essential qualities
Demonstrate	Show by example
Describe	Provide characteristics and features
Discuss	Identify issues and provide points for and/ or against
Distinguish	Recognise or note/ indicate as being distinct or different from; to note differences between
Evaluate	Make a judgement based on criteria; determine the value of
Examine	Inquire into
Explain	Relate cause and effect; make the relationships between things evident; provide why and/or how
Extract	choose relevant and/ or appropriate details
Extrapolate	Infer from what is known
Identify	Recognise and name
Interpret	Draw meaning from
Investigate	Plan, inquire into and draw conclusions about
Justify	Support an argument or conclusion
Outline	Sketch in general terms; indicate the main features of
Predict	Suggest what may happen based on available information
Propose	Put forward (for example a point of view, idea, argument, suggestion) for consideration or action
Recall	Present remembered ideas, facts or experiences
Recommend	Provide reasons in favour
Recount	Retell a series of events
Summarise	Express, concisely, the relevant details
Synthesise	Putting together various elements to make a whole

DATA SHEET

Avogadro constant, N_A ..... 6.022×10^{23} mol^{-1}

Volume of 1 mole ideal gas: at 100 kPa and

at 0°C (273.15 K) ..... 22.71 L

at 25°C (298.15 K) ..... 24.79 L

Ionisation constant for water at 25°C (298.15 K), K_w ..... 1.0×10^{-14}

Specific heat capacity of water ..... 4.18×10^3 J kg^{-1} K^{-1}

Some useful formulae

$$pH = -\log_{10}[H^+] \qquad \Delta H = -mC\Delta T$$

Some standard potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	–0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1.36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2.89 V

Aylward and Findlay, *SI Chemical Data* (5th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number
Atomic Weight
79 Au 197.0 Gold
Symbol of element
Name of element

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.41 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [97.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [209.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223] Francium	88 Ra [226] Radium	89–103 Actinoids	104 Rf [261] Rutherfordium	105 Db [262] Dubnium	106 Sg [266] Seaborgium	107 Bh [264] Bohrium	108 Hs [277] Hassium	109 Mt [268] Meitnerium	110 Ds [271] Darmstadtium	111 Rg [272] Roentgenium							

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [145] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac [227] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237] Neptunium	94 Pu [244] Plutonium	95 Am [243] Americium	96 Cm [247] Curium	97 Bk [247] Berkelium	98 Cf [251] Californium	99 Es [252] Einsteinium	100 Fm [257] Fermium	101 Md [258] Mendelevium	102 No [259] Nobelium	103 Lr [262] Lawrencium

For elements that have no stable or long-lived nuclides, the mass number of the nuclide with the longest confirmed half-life is listed between square brackets.
The International Union of Pure and Applied Chemistry Periodic Table of the Elements (October 2005 version) is the principal source of data. Some data may have been modified.