

LEAVING  
CERTIFICATE

# CHEMISTRY

**DRAFT SYLLABUS  
FOR CONSULTATION**

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# SENIOR CYCLE

THE EXPERIENCE OF SENIOR CYCLE

# Senior cycle

## Introduction

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Learners in senior cycle are approaching the end of their time in school and are focusing on the directions they would like to take in their future lives. Senior cycle plays a vital role in helping learners to address their current needs as young adults and in preparing them for life in a changing economic and social context.

Senior cycle is founded on a commitment to educational achievement of the highest standard for all learners, commensurate with their individual abilities. To support learners as they shape their own future there is an emphasis on the development of knowledge and deep understanding; on learners taking responsibility for their own learning; on the acquisition of key skills; and on the processes of learning.

The broad curriculum, with some opportunities for specialisation, supports continuity from junior cycle and sets out to meet the needs of learners, some of whom have special educational needs, but who all share a wide range of learning interests, aptitudes and talents.

The range and scope of the curriculum components offered at senior cycle—subjects, short courses, transition units and curriculum frameworks—have been developed to allow for choice and flexibility, for a balance between knowledge and skills, and for the promotion of the kinds of learning strategies relevant to participation in and contribution to a changing world where the future is uncertain.

Assessment in senior cycle involves gathering, interpreting and using information about the processes and outcomes of learning. It takes different forms and can be used for a variety of purposes. It can be used to determine the appropriate route for learners through a differentiated curriculum, to identify specific areas of difficulty or strength for a given student and to test and certify achievement. Assessment can support and improve learning by helping learners and teachers to identify next steps in the teaching and learning process.

## The experience of senior cycle

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The vision of senior cycle sees the learner at the centre of the educational experience. That experience will enable learners to be resourceful, to be confident, to participate actively in society, and to build an interest in and ability to learn throughout their future lives.

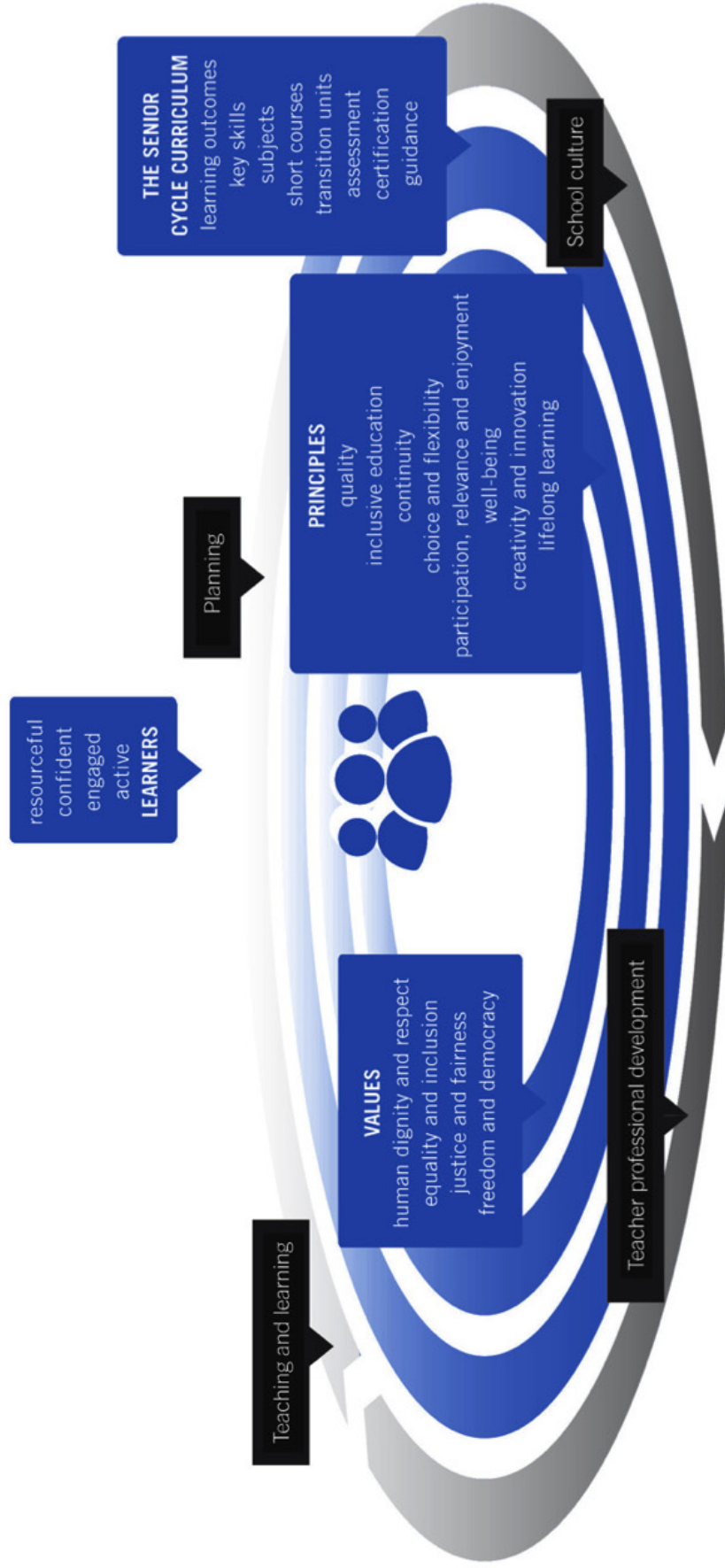
This vision of the learner is underpinned by the values on which senior cycle is based and it is realised through the principles that inform the curriculum as it is experienced by learners in schools. The curriculum, made up of subjects and courses, embedded key skills, clearly expressed learning outcomes, and supported by a range of approaches to assessment, is the vehicle through which the vision becomes a reality for the learner.

At a practical level, the provision of a high quality educational experience in senior cycle is supported by

- effective curriculum planning, development, organisation and evaluation
- teaching and learning approaches that motivate and interest learners, that enable them to progress, deepen and apply their learning, and that develop their capacity to reflect on their learning
- professional development for teachers and school management that enables them to lead curriculum development and change in their schools
- a school culture that respects learners, that encourages them to take responsibility for their own learning over time, and that promotes a love of learning.

Senior cycle education is situated in the context of a broader education policy that focuses on the contribution that education can make to the development of the learner as a person and as a citizen. It is an education policy that emphasises the promotion of social cohesion, the growth of society and the economy, and the principle of sustainability in all aspects of development.

## Overview of senior cycle





**LEARNERS  
COMPLETING  
SENIOR  
CYCLE  
ARE**

**RESOURCEFUL**

they show their imagination, intelligence, intuition and other talents through

- curiosity
- enquiry
- open-mindedness
- reflection
- connecting learning
- innovation
- problem solving
- creativity

**CONFIDENT**

they develop their physical and mental well-being and become self-aware

- have high self-efficacy
- engage with ethics, values and beliefs
- welcome opportunities
- can cope with setbacks
- can effect positive change



**ENGAGED**

they participate in the social, community, national and international dimensions of their lives by showing respect for others

- forming and sustaining caring relationships
- making informed decisions
- building practical know-how
- taking interest in and responsibility for their social and physical environment
- developing moral/ethical and political understanding
- making lifestyle choices that are sustainable
- contributing to their own material well-being and the material well-being of society

**ACTIVE LEARNERS**

they pursue excellence in learning to the best of their ability and develop a love of learning by seeking and using knowledge, and understanding how knowledge is created

- experiencing passion for, rigour in and commitment to learning
- developing intellectual and critical thinking skills
- exercising autonomy and independence in learning
- managing their learning and making learning choices
- setting and achieving learning goals
- pursuing learning qualifications







# **CHEMISTRY**

**INTRODUCTION**

**AIM**

**OBJECTIVES**

**RELATED LEARNING**

## Introduction

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**Science education** provides a means by which learners can interact with the world around them and understand how scientific concepts can be used to make sense of the physical world. As learners' scientific literacy grows they will be able to make sense of the various ways in which scientific knowledge is communicated. Science is a human construct; scientific knowledge is constructed by the sharing of ideas and by developing, refining, and rejecting or accepting of these ideas. Through engagement with science learners will acquire the knowledge skills, attitudes and values that will allow them to take informed positions on scientific issues. As well as constructing knowledge of science they will construct knowledge about science and the nature of science including its moral and ethical dimensions.

**Chemistry** is the study of matter and its interactions. Many of today's contemporary issues require the knowledge and understanding of fundamental chemical principles. The chemistry syllabus has been designed to develop essential knowledge and understanding of chemical facts, concepts and principles together with an appreciation of their significance, and the skills needed for their use in new and changing situations.

Learners will draw on their knowledge and understanding of the facts, principles and concepts from different areas of chemistry to evaluate and use arguments about the place of chemistry in society. They will develop an appreciation of the significance of chemistry in personal, social, environmental, economic and technological contexts and an awareness of advances in technology, including ICT, relevant to chemistry.

Practical skills are seen as an integral accompaniment to theory. Investigation and the theories that arise from experimentation are central to the study of chemistry. Learners will develop an understanding of the links between theory and experiment and develop an understanding of scientific process. The syllabus is designed for all learners; the skills developed will form part of their lifelong learning and prepare them both for the workplace or for further studies in chemistry.

# Aim

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Chemistry aims to stimulate and sustain learners' interest in and enjoyment of chemistry while developing an understanding of the fundamental principles underlying chemical phenomena and illustrating how humanity has benefited from the study and practice of chemistry.

# Objectives

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The objectives of Leaving Certificate Chemistry are to

- enable learners to build on their existing knowledge and understanding of chemistry terminology, facts, principles and methods and to develop the skills needed to apply this knowledge and understanding to familiar and unfamiliar situations
- develop understanding of how materials react and how they can be put to use, and to appreciate the usefulness of chemical products
- develop skills in scientific inquiry including the ability to interpret and analyse qualitative and quantitative data from different sources and to consider the validity and reliability of data in presenting and justifying conclusions
- develop skills in laboratory procedures and techniques, including the use of ICT, carried out with due regard for safety, together with the ability to assess the uses and limitations of these procedures through engagement in a wide variety of practical activities
- develop in learners the ability to explain, evaluate and communicate the results of their experimental and investigative activities in verbal, graphical and mathematical form, using ICT where appropriate
- encourage learners to develop an understanding of the ethical, historical, environmental, and technological aspects of chemistry, and how chemistry contributes to the social and economic development of society

## Related learning

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### Early Childhood

*Aistear*, the early childhood curriculum framework, celebrates early childhood as a time of well-being and enjoyment where children learn from experiences as they unfold.

The theme of Exploring and Thinking is about children making sense of the things, places and people in their world by interacting with others, playing, investigating, questioning, and forming, testing and refining ideas.

Children use their senses, their minds and their bodies to find out about and make sense of what they see, feel and experience in the world around them. They gather information and develop new skills, including thinking skills. They form ideas and theories and test these out. They refine their ideas through exploring their environment actively and through interacting and communicating with adults and with other children. Much of this happens through play and other experiences that allow children to be creative, to take risks, and to make discoveries. As they learn, they retest their theories adjusting them to take on board new discoveries and new experiences.

### Primary School

Social, environmental and scientific education (SESE) provides opportunities for the child to explore and investigate the world around them from a human, social and cultural perspective. Objects and events in science are experienced in reality before being the subject of mental manipulation.

### Junior Cycle

Junior cycle science places student learning in the context of science activities, emphasising hands-on engagement through which learners develop their understanding of the scientific concepts and principles involved together with appropriate science process skills. This approach provides continuity with science in the Primary School Curriculum. There is an emphasis on an investigative approach, through which learners develop an understanding and appreciation of activities and processes that are fundamental to all science together with the ability to apply science principles to their everyday lives. Many junior cycle subjects have close links with science, particularly: geography, CSPE, PE, SPHE, home economics and religious education.

### Senior Cycle

Learners build on their science process skills and use them to develop deeper understanding of scientific concepts. Many senior cycle subjects have close links with chemistry, including: agricultural science, physics, chemistry, biology, geography, home economics, religious education, and mathematics. Chemistry is not learned in isolation. It has significant, though varied, connections with other curriculum subjects. For example, concepts such as sustainable development are core to many subjects at senior cycle, and the knowledge and understanding gained in chemistry can be used in conjunction with that learned in other subjects to enrich overall learning. Many topics studied in chemistry overlap with topics covered in other subjects. Chemistry by its nature is quantitative and learners are expected to be able to work with data and produce graphs and interpret patterns and trends.

### Further Study

The chemistry syllabus provides a suitable foundation for the study of chemistry or a related area through a range of higher education courses or direct entry into employment. A chemistry qualification can lead to many exciting and rewarding careers. Apart from pure chemistry, there is a diverse range of opportunities in related areas which include, amongst others—materials chemistry, biotechnology, biochemistry, medicinal chemistry, engineering, geochemistry, environmental chemistry and forensic science

### Community and Society

Learners will develop an appreciation of the social and cultural perspectives of chemistry and of the impact of science and technology on people and on the environment. For example, understanding and ability to manipulate chemical molecules, have allowed for the development of crop-enhancing agricultural chemicals to ensure a constant and viable food supply, deadly diseases have been eradicated by developing life-saving pharmaceuticals and chemical pesticides. Chemists also developed plastics and synthetic fibres for use in a both industrial and consumer products. All of these advances come at some cost to the environment; studying chemistry will assist learners in making informed decisions about the value of a chemical to society versus its inherent impact on the environment.

# SYLLABUS OVERVIEW



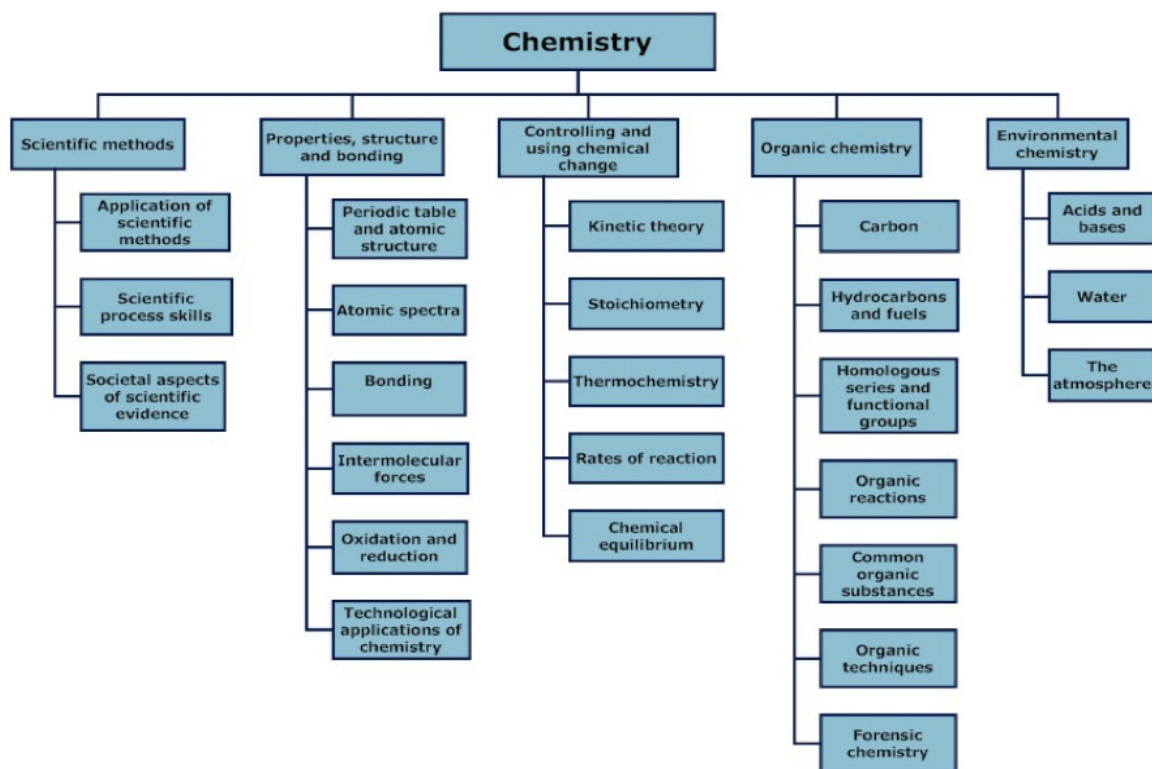
STRUCTURE  
TIME ALLOCATION  
KEY SKILLS  
TEACHING AND LEARNING  
DIFFERENTIATION



# Syllabus overview

## Structure

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The chemistry syllabus is divided into five sections reflecting major branches of chemistry. The first unit, scientific methods, sets the context for the four units that follow. The course content is gathered into topics on properties, structure and bonding, controlling and using chemical change, organic chemistry and environmental chemistry.

The syllabus is presented in learning outcomes. The outcomes are statements of what the learner should know and be able to do having completed the unit of study. The sequence in which the learning outcomes are presented does not imply any particular order of teaching and/or learning.

## Time Allocation

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The chemistry syllabus is designed for 180 hours of class contact time. It is recommended that some class periods should be timetabled consecutively to ensure at least one double class per week and thus facilitate meaningful learner engagement in practical activities.

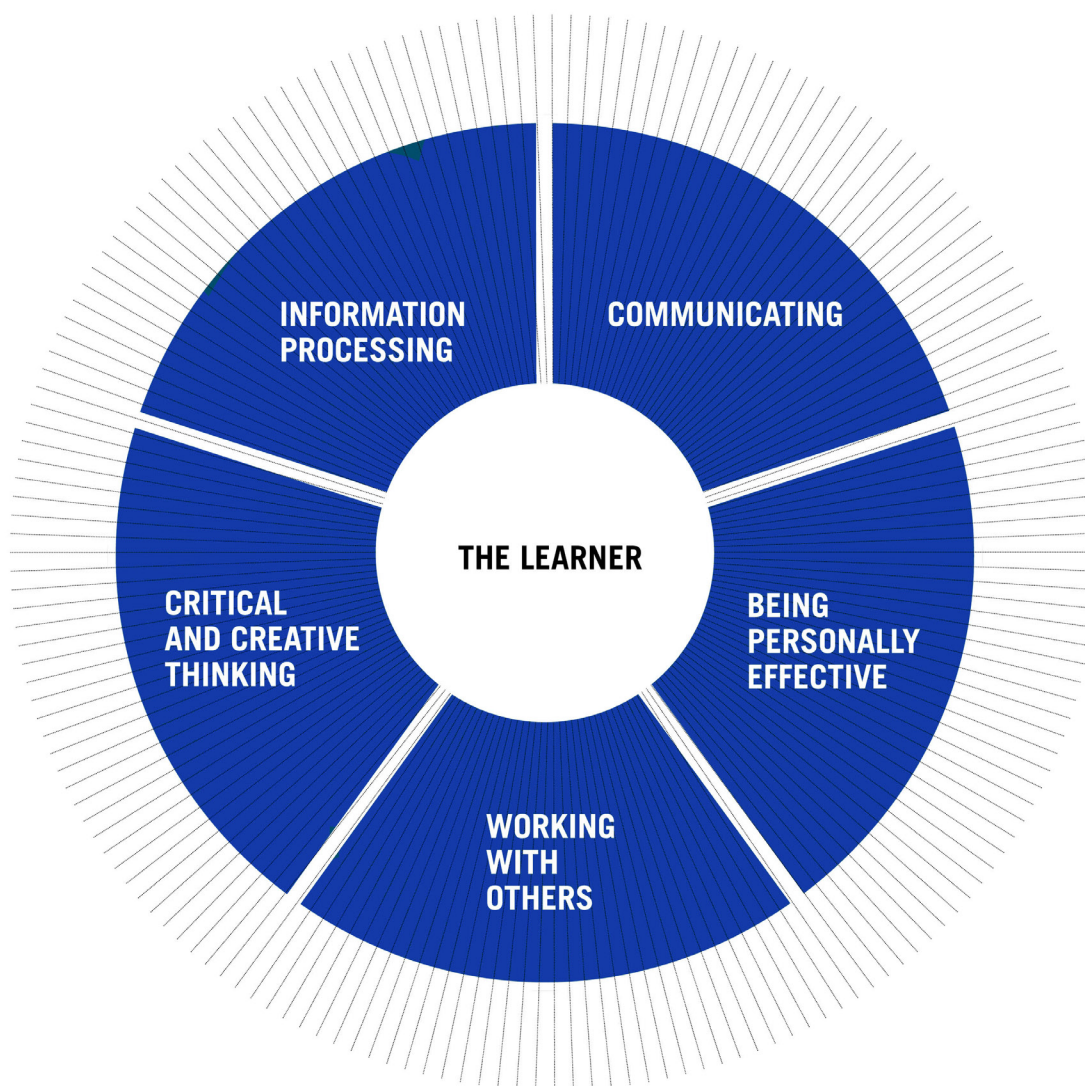
## Practical Activities

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Learners must complete the practical activities specified in the syllabus. Over the two years of the course each learner is required to maintain a record of these activities.

## Key skills

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There are five skills identified as central to teaching and learning across the curriculum at senior cycle. These are information processing, being personally effective, communicating, critical and creative thinking and working with others. These key skills are important for all learners to achieve their full potential, both during their time in school and into the future and to participate fully in society, including family life, the world of work and lifelong learning. Learners develop key skills which enhance their abilities to learn, broaden the scope of their learning and increase their capacity for learning. The syllabus is designed to help learners develop skills as they build on their knowledge and understanding of chemistry, form positive attitudes to learning and acquire good values through their learning experiences. The key skills are embedded within the learning outcomes of the syllabus and will be assessed in the context of the assessment of the learning outcomes

Learners will engage with the fundamental principles and concepts of chemistry through participation in a wide range of skills-based activities. They will build on their knowledge of chemistry constructed initially through their exploration of science in the Primary School Curriculum and through their investigations in Junior Certificate Science. They will develop information processing and critical and creative thinking skills by examining patterns and relationships, analysing hypotheses, exploring options, solving problems and applying those solutions to new contexts. The Leaving Certificate chemistry syllabus offers the opportunity for learners to work together to research design, plan and conduct investigations and to communicate their findings.

In solving chemistry problems learners will use careful observation, thoughtful analysis and clarity of expression to evaluate evidence, give their own interpretation of that evidence and make a clear presentation of their

proposed solution. Students will learn how to research up-to-date and balanced information that they can use to develop a critical approach to accepted chemistry theories and beliefs and in doing so come to understand the limitations of science.

A wide range of activities is appropriate for chemistry, including among others, experimental and investigative activities, poster presentations, research activities and debates. Participation in these activities will mirror the work of scientists and enable learners to connect their experience with the theoretical concepts of chemistry.

In working with others to achieve shared goals, learners develop skills of communication as they share their ideas and present their work using a variety of media. The syllabus learning outcomes encourage learners to make reasoned arguments and to express and justify their position.

## Practical Activities

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Included in the syllabus learning outcomes are a number of practical activities which are categorised under three headings

- **prescribed activities** develop skills in science process, laboratory techniques and safety procedures. These skills include: following experimental procedure, identifying controls and variables, collecting and recording data, observing and measuring, analysing data for patterns and meaning, and communicating conclusions
- **open-ended, investigative activities** develop skills in application of the strategies of scientific inquiry. These skills include identifying and refining good inquiry questions, developing testable hypotheses, initiating and planning, performing and recording, analysing and interpreting, problem solving and evaluating results
- **research** activities develop skills in accessing information that has been previously gathered, selecting the relevant details, analysing that information for patterns and meaning, and communicating their findings or conclusion.

All forms of practical activities throughout the course develop communication skills. Although the traditional written report is one form of communication, learners will describe what they do and what they learn in other formats as well – such as poster presentations, computer presentations or video. Through various formats of co-operative learning, they will discuss, debate, and reflect on their own thinking and learning. As well as reinforcing the understanding of concepts, principles, laws, and theories the practical activities will support the development of key skills in a variety of contexts. The scientific approach, interpretation of data and use of evidence and argument in evaluating information are central to both the practical activities and the theoretical concepts.

## Teaching and learning

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Senior cycle learners are encouraged to develop the knowledge, skills, attitudes and values that will enable them to become independent learners and to develop a lifelong commitment to improving their learning.

Leaving Certificate chemistry supports the use of a wide variety of teaching and learning approaches. As learners progress they will develop learning strategies that will be transferable across different tasks and different subjects enabling them to make connections between chemistry, other subjects and everyday experiences. Through engaging in self-directed activities and reflection, learners will assume much of the responsibility for planning, monitoring and evaluating their own learning and in doing so will develop a positive sense of their own capacity to learn. By engaging in group work, learners will develop skills in reasoned argument, listen to each other, inform one another of what they are doing and reflect on their own and on the work of others.

Learners will integrate their knowledge and understanding of chemistry with the ethical, social, economic and environmental implications and applications of chemistry. Increasingly, arguments between scientists are the subject of public and media comment. By critically evaluating scientific texts and debating public statements about science, learners will engage with contemporary issues in chemistry that affects their everyday lives. They will learn to interrogate and interpret data—a skill which has a value far beyond chemistry wherever data are used as evidence to support argument. By providing an opportunity to examine and debate reports about contemporary issues in science, chemistry will enable learners to develop an appreciation of the social context of science. The variety of activities that learners engage in enables them to take charge of their own learning by setting goals, developing action plans and receiving and responding to assessment feedback. As well as varied teaching strategies, varied assessment strategies will provide information that can be used as feedback so that teaching and learning activities can be modified in ways which best suit individual learners available.

### Information and communication technology (ICT)

Computer applications should be included in activities whenever they enhance student learning by enabling them to complete work more efficiently or to complete work that otherwise could not be done. A wide variety of software tools should be used to collect, record, analyse and display information. Examples include reports, spread sheets, graphics, flow charts, concept maps, databases, and electronic presentation. Sensors and

other appropriate hardware should be used to collect data where appropriate. The portability of sensor laboratory systems makes them useful for work outside as well as inside the classroom. Software simulations offer access to science experiments that may be difficult to illustrate in other ways; they are easy to relate to and immediately useful. Whilst simulations may substitute for experiences they should not be used to replace direct experiences that are safe, ethical, and available.

## Differentiation

Differentiation occurs in three distinct areas: the learning outcomes of the syllabus, the process of teaching and learning, and assessment.

### Learning outcomes

Ordinary level	Higher level
<p>Only the learning outcomes that are not presented in bold type</p> <p>Learners engage with a broad range of knowledge, mainly concrete in nature, but with some elements of abstraction or theory. They will be expected to demonstrate and use a moderate range of practical and cognitive skills and tools, select from a range of procedures and apply known solutions to a variety of problems in both familiar and unfamiliar contexts.</p>	<p>All learning outcomes <b>including those in bold type</b></p> <p>Learners engage with a broad range of knowledge including theoretical concepts and abstract thinking with significant depth in some areas. They will be expected to demonstrate and use a broad range of specialised skills and tools to evaluate and use information, to plan and develop investigative strategies and to determine solutions to varied, unfamiliar problems. They will be expected to identify and apply skill and knowledge to a wide variety of both familiar and unfamiliar contexts.</p>

### Teaching and Learning

Learners vary in the amount and type of support they need to be successful. Levels of demand in any activity will differ as learners bring different ideas and levels of understanding to the learning activity. The use of strategies for differentiated learning such as adjusting the level of skills required, varying the amount and the nature of teacher intervention and varying the pace and sequence of learning will allow learners to interact at their own level.

### Assessment

In common with other syllabuses for national certification, chemistry will be assessed at both Higher and Ordinary Levels. Those sections of the syllabus designated for Higher Level students only appear in **bold type**. Differentiation at the point of assessment will be reflected in the structure of the examination paper and in the style of questioning. Consideration will be given to the language level in the examination questions, the stimulus material provided, the structure of the questions and the amount of support provided for examination candidates, especially at Ordinary Level.



# UNITS OF STUDY

**UNIT 1: SCIENTIFIC METHODS**

**UNIT 2: PROPERTIES, STRUCTURES AND BONDING**

**UNIT 3: CONTROLLING AND USING CHEMICAL CHANGE**

**UNIT 4: ORGANIC CHEMISTRY**

**UNIT 5: ENVIRONMENTAL CHEMISTRY**



# Units of Study

## Unit 1: Scientific methods

In addition to the ability to understand and apply the concepts, laws and theories of science, as specified throughout the syllabus, learners should also be able to understand scientific methods and apply them in a variety of contexts. They should be competent in understanding the body of knowledge relating to the pursuit of suitable evidence that underpins scientific practice. Understanding methods of collection, analysis and interpretation of data and being able to evaluate scientific evidence will enable learners to question and engage in debate on the evidence used to defend a scientific claim. This section contains learning outcomes that learners need to achieve so that the syllabus objectives are fully met.

Students learn about	Students should be able to
1.1 Application of scientific method	<ul style="list-style-type: none"><li>• apply their knowledge and understanding of science to develop arguments or draw conclusions related to both familiar and unfamiliar situations</li><li>• use secondary data sources; locate and comprehend relevant information from books, scientific publications, internet, databases and other resources</li><li>• make judgements and draw informed conclusions pertaining to the reliability and validity of data</li><li>• use observations as the basis for formulating a hypothesis</li></ul>
1.2 Scientific process skills	<ul style="list-style-type: none"><li>• identify variables and select appropriate controls</li><li>• design, manage and carry out experimental and non-experimental investigations; select appropriate measuring devices; use scales and units accurately, being aware of limitations and errors</li><li>• collect, organise, interpret, present and analyse primary and secondary data</li><li>• describe relationships (qualitatively and/or quantitatively) between sets of data; recognising the difference between causation and correlation</li><li>• consider the validity and reliability of data in presenting and justifying conclusions</li></ul>
1.3 Societal aspects of scientific evidence	<ul style="list-style-type: none"><li>• critically examine the scientific process that was used to present a scientific claim</li><li>• appreciate the limitations of scientific evidence</li></ul>

## Unit 2: Properties, structures and bonding

This unit introduces learners to the structure of the atom, the building block of matter. They learn how the contributions of key scientists have advanced the knowledge of atomic and molecular theory. They explore the relationship between the position of elements in the periodic table and their properties. They discover how the properties of compounds are determined by the type of bonding present. Throughout the unit, the relationship between atomic structure, chemical reactivity and the position that an element occupies in the Periodic Table is developed.

Students learn about	Students should be able to
2.1 Periodic table and atomic structure	<ul style="list-style-type: none"><li>• describe and contextualise the contributions of the Greeks, Boyle, and Dalton to the historical development of the idea of elements</li><li>• describe and contextualise the contributions of Mendeleev, <b>Dobereiner</b>, <b>Newlands</b>, and <b>Moseley</b>; that led to the idea of elements and the systematic arrangement of the elements</li><li>• extract relevant information for the first 36 elements in the Periodic Table from the “formulae and tables” booklet</li><li>• distinguish the terms elements, compounds, mixture, atom, molecule and ion</li><li>• describe and discuss the atomic models presented by Dalton, Thomson, Rutherford, Bohr and <b>Schrödinger</b>, and explain how these models were underpinned by experimental evidence</li><li>• contextualise the contributions of <b>Crookes</b>, <b>Heisenberg</b> and <b>de Broglie</b> to the development of atomic theory</li><li>• <b>use the development of the atomic theory to illustrate how experimental evidence informs scientific thinking</b></li><li>• carry out practical activities that demonstrate the particulate nature of matter (e.g. crystal growth, Brownian motion, diffusion, compression/ expansion of gases)</li><li>• explain the meaning of the terms: atomic number, mass number, isotope, relative atomic mass</li><li>• outline the principles and describe the processes of mass spectrometry (vaporisation, ionisation, acceleration, separation and detection)</li><li>• <b>interpret simple mass spectrometry data to determine isotopic abundances and calculate relative atomic mass using mass spectra data</b></li></ul>

2.2 Atomic spectra	<ul style="list-style-type: none"> <li>• write and account for the electronic structures of atoms in respect of numbers of electrons in each energy level for the first twenty elements</li> <li>• <b>build up the electronic structure of the first 36 elements and simple ions (s, p, d electron configuration)</b></li> <li>• explain how emission and absorption spectra arise</li> <li>• carry out of a qualitative practical activity into continuous and line absorption and emission spectra using a spectrometer and evaluate the findings</li> <li>• carry out and evaluate the findings of practical activities, using a spectrometer, of the emission spectra associated with a clean Bunsen flame and Bunsen flames to which a colour has been imparted using metal salts (K, Na, Cu, Li, Ba and Sr)</li> <li>• conduct an activity to identify the presence of the following metal salts K, Na, Cu, Li, Ba, Sr in an unknown salt</li> <li>• <b>describe and account fully for trends in first ionisation energy and atomic radius of the s and p block elements across periods and down groups for the first 36 elements</b></li> <li>• <b>describe how successive ionisation energy values provide evidence for the existence of energy levels</b></li> <li>• interrelate the chemical properties of elements to their electronic structure and their placement in the periodic table</li> <li>• conduct activities to demonstrate the characteristic properties of transition elements i.e. variable valency, colour change and the ability to act as a catalyst</li> </ul>
2.3 Bonding	<ul style="list-style-type: none"> <li>• describe and explain valency and bonding in terms of the attainment of stable electronic configurations (noble gas configurations); represent ionic and covalent bond types using dot and cross diagrams</li> <li>• <b>describe bonding in terms of orbital overlap and distinguish the type of overlap involved in sigma and pi bonding</b></li> <li>• define electronegativity and account for the trends in electronegativity values shown across periods and down groups in the periodic table</li> <li>• use electronegativity values to predict polarity in a covalent bond</li> <li>• relate the chemical and physical properties of compounds to the types of bonding present</li> <li>• carry out qualitative tests to determine the presence of anions (chlorides, iodides, sulfites, sulfates, carbonates, and hydrogencarbonates) in aqueous solutions and use these tests to identify the anion in an unknown salt (half equations required)</li> <li>• observe and explain how a thin stream of a polar liquid is deflected towards both positively and negatively charged rods whilst a thin stream of a non-polar liquid is undeflected</li> <li>• use valence shell electron pair repulsion theory (VSEPR) to determine and account for the shape and bond angles of molecules of type AB<sub>n</sub> for up to four VSEPR pairs of electrons around a central atom</li> <li>• use models and/or computer software to construct a range of molecules of the form AB<sub>n</sub> for up to four VSEPR pairs of electrons around a central atom</li> </ul>

2.4 Intermolecular forces	<ul style="list-style-type: none"> <li>• describe and account for the range of intermolecular forces (i)hydrogen bonding, (ii)weak permanent dipole-dipole forces, (iii)weak transient dipole-dipole forces, which collectively fall under the umbrella of Van der Waals' forces</li> <li>• explain how intermolecular forces can be used to account for variances in physical phenomena (solubility, melting point and boiling point)</li> <li>• carry out a practical activity to investigate the temperature loss during evaporation of a range of organic liquids</li> <li>• conduct an activity using a conductivity sensor to investigate the relative ability of i) different solutions of salts of the same concentration and ii) different concentrations of the same salt, to conduct an electric current</li> <li>• distinguish between intermolecular forces and intramolecular bonding</li> <li>• distinguish between amorphous and crystalline solids</li> <li>• outline qualitatively how crystal structures are determined</li> <li>• outline the contributions of William and Lawrence Bragg, Dorothy Hodgkin and <b>Kathleen Lonsdale</b> to crystallography</li> <li>• compare ionic, molecular, covalent macromolecular and metallic crystals under the following headings (i)species occupying lattice points, (ii)binding forces and (iii) physical properties</li> <li>• construct a model of a crystal</li> <li>• describe and discuss the existence and nature of allotropes</li> <li>• describe and discuss the structure and properties of the allotropes of carbon (diamond, graphite, buckyball, carbon nanotubes)</li> </ul>
2.5 Oxidation and reduction	<ul style="list-style-type: none"> <li>• describe using simple examples how oxidation and reduction can be explained in terms of electron transfer</li> <li>• explain the terms oxidising agent and reducing agent</li> <li>• determine the oxidation number of an element in a compound by the application of the relevant rules and using a knowledge of oxidation and reduction processes</li> <li>• <b>use oxidation numbers to balance redox equations</b></li> <li>• describe the process that occurs in an electrochemical cell</li> <li>• <b>write the half equations that occur at the electrodes in the electrolysis of (i) acidified water,(ii)aqueous sodium sulfate and (iii) aqueous potassium iodide</b></li> <li>• observe and account for what occurs at each electrode during the electrolysis of (i) aqueous sodium sulfate (using universal indicator) and (ii) aqueous potassium iodide (using phenolphthalein indicator)</li> <li>• conduct an activity to demonstrate the displacement of metals</li> </ul>

2.6 Technological applications of chemistry

- **apply knowledge of electrochemistry to explain how corrosion occurs and outline the principles that underpin four different processes of prevention**
- describe and discuss the difference between a named rechargeable battery and a named non-rechargeable battery
- discuss how the advances in the hydrogen fuel cell have facilitated the development of electric cars
- conduct a practical activity to demonstrate the use of fuel cells
- **discuss the terms : nanoscience, nanochemistry and nanotechnology**
- **describe and discuss how incorporation of carbon nanotubes into polymer composites can alter the mechanical properties of these composites**
- **describe/discuss the electronic properties and potential applications of carbon nanotubes**



## Unit 3: Controlling and using chemical change

This unit begins with the kinetic theory of gasses and how it led to the concept of the mole, which is used extensively in chemical calculations. It describes the energy changes in chemical reactions, the factors which influence the rate of chemical reactions and how optimal conditions can be achieved in equilibrium reactions. Students will learn how scientists put this knowledge to work in the chemical industry as they consider ways in which adjustment of conditions may be used to favour particular, desired, chemical outcomes

Students learn about	Students should be able to
3.1 Kinetic theory	<ul style="list-style-type: none"><li>• describe and discuss the assumptions of the Kinetic Theory of Gases and the evidence for this theory (Brownian motion)</li><li>• describe using the kinetic theory model, the solid, liquid and gaseous states of matter and the changes that occur during melting and vapourisation</li><li>• explain what is meant by the ideal gas; and account for the deviation of real gases from ideal gas behaviour</li><li>• state Boyle's and Charles' Laws</li><li>• explain Boyle's Law and Charles' Law in terms of the kinetic theory; interpret graphs related to Boyle's and Charles' laws</li><li>• <b>solve problems using the Combined Gas Law (General Gas Law)</b> <math>P_1V_1/T_1 = P_2V_2/T_2</math></li><li>• <b>solve problems using the Equation of State for an ideal gas <math>PV=nRT</math> (units: Pa, m<sup>3</sup>,K)</b></li><li>• conduct an activity to determine experimentally, the value of the Universal Gas Constant (R) using sensor technology</li></ul>

### 3.2 Stoichiometry

- explain how the laws proposed by Gay-Lussac and Avogadro led to the application of stoichiometry to gaseous reactions
- explain the concept of the mole
- define the mole
- explain and carry out calculations involving relative atomic masses, relative molecular masses, relative formula masses, molar volumes and Avogadro's constant
- conduct an activity to determine the relative molecular mass of a volatile liquid
- distinguish between empirical and molecular formulae
- carry out calculations to determine percentage composition of compounds and use these data to determine empirical formula and molecular formulae
- **carry out calculations based on balanced equations using the mole concept to determine (i) numbers of moles and masses of reactants and products (ii) volumes of gases (iii) exact stoichiometric amounts and limiting reagent (iv) percentage yields. (These calculations limited to g and kg as units of mass and may include volumes and numbers of molecules or atoms)**
- calculate and inter-relate concentrations of solutions in terms of g/L, mol/L %w/w, %w/v, %v/v, and ppm; including expressions of concentrations within everyday examples
- conduct an activity to prepare stock solutions of a coloured compound and use them to construct a calibration curve with the aid of a colorimeter; use the calibration curve to determine the concentration of a solution of this compound
- explain the terms primary standard and standard solution
- explain the concept of a titration
- describe and account for the appropriateness of the apparatus used in volumetric analysis and the standard procedure for carrying out a titration
- carry out titrimetric calculations limited to (i) acid/base titration and (ii) redox titration where all necessary equations and data are supplied
- conduct an activity to prepare a standard solution of sodium carbonate and use this solution to determine the concentration of a solution of hydrochloric acid
- conduct a practical activity to determine by titrimetric method the concentration of ethanoic acid in vinegars, iron in iron supplements and hypochlorite in bleaches
- conduct a practical activity to determine by titrimetric method the concentration of a compound in an everyday product

### 3.3 Thermochemistry

- explain how chemical changes can result in changes in temperature
- explain in simple terms the concept of entropy
- explain the terms enthalpy, exothermic and endothermic, heat of reaction, heat of combustion, heat of formation, heat of neutralisation, calorific fuel value and bond energy
- conduct an activity to determine the enthalpy of reaction of a strong and a weak acid with sodium hydroxide
- relate energy changes to bond breaking and bond formation; use bond energy values to quantitatively predict the enthalpies of reaction
- interpret calorific values of fuels
- including foods
- describe examples of technologies that depend on exothermic and endothermic reactions in everyday life
- describe and interpret energy profiles for chemical reactions
- state Hess's Law
- define and discuss the Law of Conservation of Energy and its relationship to Hess's Law
- conduct an activity to determine the heat of combustion of magnesium by measuring the enthalpies of reaction of both magnesium and magnesium oxide with hydrochloric acid
- **perform calculations using Hess's Law to determine enthalpy changes for chemical reactions (no more than three chemical equations to be given in any one problem)**

3.4 Rates of reaction	<ul style="list-style-type: none"> <li>• define rate of reaction</li> <li>• use experimental data to determine</li> <li>• average <b>and instantaneous</b> rates of reaction</li> <li>• outline the basis that underpins the collision theory</li> <li>• explain in terms of the collision theory how concentration, particle size, temperature, nature of reactants and presence of a catalyst affect the rate of a reaction</li> <li>• conduct an activity to investigate the effect of concentration, temperature on the rate of a reaction</li> <li>• explain the term catalyst</li> <li>• demonstrate how particle size, nature of reactants and presence of a catalyst effect the rate of a reaction</li> <li>• <b>distinguish between homogeneous and heterogeneous catalysis</b></li> <li>• <b>discuss using suitable examples how homogeneous and heterogeneous catalysis occurs</b></li> <li>• <b>discuss and describe evidence for autocatalysis in reactions involving the reduction of the manganese(VII) ion</b></li> <li>• conduct activities to demonstrate homogeneous and heterogeneous catalysis</li> <li>• describe the operation of catalytic converters in cars [include the nature and type of catalyst and the reactions catalysed]</li> <li>• discuss the importance of developing catalysts (including enzymes) to reduce the economic and environmental cost of industrial processes</li> <li>• <b>relate the Collision Theory to the kinetic theory of gases and identify the activation energy from reaction profile diagrams; explain how the presence of a catalyst modifies a reaction profile diagram</b></li> <li>• <b>describe and interpret the Boltzmann distribution curve and relate this to Activation energy</b></li> </ul>
3.5 Chemical equilibrium	<ul style="list-style-type: none"> <li>• define chemical equilibrium</li> <li>• explain the concept of dynamic chemical equilibrium</li> <li>• state Le Chatelier's principle; apply the principle to a variety of processes to predict disturbances to the equilibrium and to predict conditions for optimising / minimising yields (application limited to homogeneous reactions)</li> <li>• conduct an activity to demonstrate that changes in concentration can affect the position of equilibrium (acid/base indicator)</li> <li>• write an expression for the equilibrium constant <math>K_c</math> for a given chemical process and explain the factors that affect the value of <math>K_c</math></li> <li>• <b>calculate values for equilibrium constants <math>K_c</math> and concentrations present at equilibrium, given appropriate data</b></li> <li>• <b>discuss the importance of a compromise between equilibrium position and reaction rate in the chemical industry</b></li> </ul>

## Unit 4: Organic Chemistry

This unit highlights the unique properties of carbon and how important it is to the structure and functioning of all living things on Earth. Compounds of carbon constitute an enormous range of materials with diverse properties which include living systems, petroleum and synthetic materials such as drugs, medicines and plastics. Organic compounds are studied by consideration of the reaction types and structural features of a number of functional groups. Learners will examine the way in which spectroscopic techniques are used to determine the molecular formulae and structures of organic compounds, with the emphasis being on problem solving rather than on spectroscopic theory. The unit includes how some of these techniques are used in the forensic investigation of crime scenes.

*[Organic series studied in this unit are alkanes, alkenes, alkynes, arenes, alcohols, aldehydes, ketones, carboxylic acids, and esters]*

Students learn about	Students should be able to
4.1 Carbon	<ul style="list-style-type: none"><li>• contextualise the scope of carbon chemistry in respect of the large numbers of known carbon compounds and (i) the ability of carbon to form chains, branched chains and rings (ii) the strength of the carbon-carbon bond and the carbon-hydrogen bond and (iii) ability of carbon to form stable bonds with other elements</li><li>• explain the bonding and account for the shapes of ethane, ethene and ethyne (aliphatic) and benzene molecules (aromatic) in terms of sigma and pi bonds</li><li>• construct mechanically or use a software program to produce 3d models to highlight the difference between (i) planar and tetrahedral carbon (ii) saturated and unsaturated hydrocarbons and (iii) aliphatic and aromatic compounds</li><li>• differentiate between structural, and geometrical isomerism (apply cis and trans naming system)</li><li>• discuss the use of cis and trans fats in our diet</li><li>• apply IUPAC rules for nomenclature to (i) simple hydrocarbons limited to molecules containing up to and including 6 carbon atoms and (ii) to the other families listed in this unit up to and including 5 carbon atoms unit</li></ul>
4.2 Hydrocarbons and fuels	<ul style="list-style-type: none"><li>• write balanced equations for the complete combustion of organic compounds up to and including molecules containing 10 carbon atoms</li><li>• discuss issues relating to the availability of fossil fuels and the environmental effects of their use</li><li>• describe in outline the general nature of crude oil, its separation into useful fractions by fractional distillation and the uses made of the products</li><li>• conduct a practical activity to extract a natural product by steam distillation e.g. clove oil</li><li>• describe the use of rotatory evaporation in the removal of a solvent from a mixture and give one example where this process is used</li><li>• explain the term octane number and how it is defined</li><li>• describe how the octane number of a fuel is improved by methods including catalytic cracking, isomerisation, reforming (dehydrocyclisation) and the use of oxygenates</li><li>• discuss the use of alcohols and biofuels as alternatives to petrol and diesel</li></ul>



<p>4.3 Homologous series and functional groups</p>	<ul style="list-style-type: none"> <li>• describe and account for the trends in the physical properties (melting points, boiling points and solubility) of any named homologous series within this unit</li> <li>• describe and account for how functional groups in an organic compound determine its chemical behaviour</li> <li>• conduct a practical activity to demonstrate qualitatively, the reactions of carboxylic acid</li> <li>• construct mechanically or use a software program to produce 3d models of a variety of organic compounds</li> <li>• identify a number of functional groups in a large molecule and predict the type of reactions that can occur</li> <li>• assess the likely chemical activity of a named biological molecule that is either a protein, amino acid or lipid</li> </ul>
<p>4.4 Organic reactions</p>	<ul style="list-style-type: none"> <li>• describe the mechanism of free radical substitution (monochlorination of methane); describe and evaluate the experimental evidence which supports this mechanism</li> <li>• describe the mechanism of electrophilic addition in alkenes (ethene only); describe and evaluate the experimental evidence which supports this mechanism</li> <li>• discuss the importance of the hydrogenation of alkene compounds in the manufacture of food</li> <li>• describe how hydrogenation reactions are carried out</li> <li>• construct balanced half equations using structural formula for the oxidation (using <math>\text{KMnO}_4</math>) of (i) alcohol to aldehyde and (ii) aldehyde to acid</li> <li>• construct balanced half equations using structural formula for the reduction of carbonyl compounds (using <math>\text{H}_2/\text{Ni}</math>) of (i) aldehydes to alcohol (ii) acid to aldehydes and (iii) ketone to secondary alcohol</li> <li>• use the dehydration of ethanol and the formation of an ester to describe an elimination reaction</li> <li>• discuss how the formation of an ester may be described as a condensation reaction and also as a substitution reaction</li> </ul>
<p>4.5 Common organic substances</p>	<ul style="list-style-type: none"> <li>• <b>discuss the importance of organic synthesis with reference to a named pharmaceutical product</b></li> <li>• explain the concept of hydrolysis reactions and relate it to the manufacture of soap</li> <li>• differentiate between the action of a soap and a detergent in aqueous solution</li> <li>• conduct an activity to prepare a sample of a soap</li> <li>• explain the terms monomer and polymer</li> <li>• distinguish between addition and condensation polymerisation</li> <li>• describe the formation of a simple addition polymer and discuss its importance in today's society</li> <li>• discuss the reasons to develop waste management strategies to deal with non-biodegradable polymers (refer to both land fill and incineration)</li> </ul>

4.6 Organic techniques	<ul style="list-style-type: none"> <li>• interpret mass spectrometry data of small organic compounds; demonstrate its use in determining the structure and molecular mass of a compound</li> <li>• outline the principles of infra-red spectroscopy and explain the units used</li> <li>• identify the following peaks (stretching frequencies only) in given infra-red spectra (i) C-H (ii) C=O and (iii) O-H</li> <li>• outline the principle and processes involved in chromatography (paper or thin layer only)</li> <li>• conduct practical activities to distinguish (i) saturated and unsaturated compounds (ii) aldehydes and ketones (iii) pure and impure solid compounds</li> </ul>
4.7 Forensic chemistry	<ul style="list-style-type: none"> <li>• outline the role of forensic chemistry in criminal investigation</li> <li>• outline the use of thin layer, gas chromatography, high performance liquid chromatography, mass spectrometry and GC/MS in forensic science</li> <li>• explain the fate of alcohol in the body [principal metabolites only] and outline the principle of the modern breathalyser</li> </ul>

## Unit 4: Environmental chemistry

Life on earth is dependent on the mantle of gases that constitute the earth's atmosphere. Weather, and its influence on the planet, occurs because of complex physical and chemical processes of atmospheric gases. Human intervention has influenced the composition of the atmosphere, and therefore has changed, and continues to change, the nature of the atmosphere's chemistry. Understanding the impacts of phenomena such as the enhanced greenhouse effect, ozone layer depletion and acid rain requires knowledge of a wide range of chemical processes. Human activities have caused changes to water tables by extraction of substances and additions, intentional or otherwise, of soluble and insoluble substances. By completing this unit learners will come to understand the importance of developing solutions to some of the environmental problems caused by these changes.

Students learn about	Students should be able to
5.1 Acids and bases	<ul style="list-style-type: none"><li>• define acid and base, and conjugate acid and conjugate base according to Brønsted-Lowry theory; use Brønsted-Lowry theory to identify species acting as acids and bases in chemical processes (limited to aqueous solutions)</li><li>• differentiate between the Arrhenius and Brønsted Lowry theories of acids and bases</li><li>• apply acid base theory to identify conjugate acid/base pairs from appropriate equations</li><li>• distinguish between the following terms when referring to acids and bases (i) weak and strong (ii) concentrated and dilute</li><li>• compare the behaviour of strong and weak acids and bases using the concept of equilibrium</li><li>• explain how an acid/base indicator functions</li><li>• discuss the importance of acids, bases and neutralisation in our everyday lives</li><li>• deduce the expression <math>K_w = [H^+][OH^-]</math> from the self-ionisation of water and explain how its value varies with temperature</li><li>• define pH as <math>-\log_{10}[H^+]</math></li><li>• calculate the pH of (i) dilute aqueous solutions of strong acids and base and (ii) dilute aqueous solutions of weak acids and bases using appropriate <math>K_a</math> and <math>K_b</math> values</li><li>• use a pH sensor to collect experimental data to plot the following pH curves; (i) strong acid-strong base, (ii) strong acid-weak base; deduce using the curve an appropriate indicator to accurately determine the end point</li><li>• <b>explain what is meant by a buffer solution</b></li><li>• <b>account qualitatively for the action of acidic and basic buffers in solutions; discuss the importance of buffer solutions in living systems and in industry</b></li></ul>

5.2 Water	<ul style="list-style-type: none"> <li>• explain the term hardness and distinguish between temporary and permanent hardness in water</li> <li>• outline three processes used to remove temporary and permanent hardness</li> <li>• perform two separate experiments that use different processes to remove hardness from water and evaluate the results</li> <li>• outline the processes involved in the large scale treatment of potable water and of domestic sewage</li> <li>• explain the concept of Biochemical Oxygen Demand (BOD) and discuss how BOD values are used</li> <li>• carry out practical activities to determine the following in respect of water samples (i) pH (ii) suspended solids content (iii) dissolved solids content (iv) conductivity (v) total hardness (vi) BOD (vii) free chlorine content</li> <li>• <b>discuss how pollution affects BOD values and explain the consequences</b></li> <li>• <b>discuss the challenges facing society resulting from increased requirements for water and better sewage treatment</b></li> </ul>
5.3 The atmosphere	<ul style="list-style-type: none"> <li>• describe the chemical composition of ozone; outline and explain the chemistry associated with ozone production and its depletion</li> <li>• explain the enhanced greenhouse effect and discuss how this effect has environmental implications for the Earth</li> <li>• explain what is meant by acid rain: discuss the environmental implications of acid rain</li> <li>• <b>critically evaluate the measures being employed in Ireland to reduce atmospheric pollution and critically compare these measures with those adopted elsewhere</b></li> </ul>



# ASSESSMENT

ASSESSMENT IN LEAVING CERTIFICATE CHEMISTRY

ASSESSMENT COMPONENTS

GENERAL ASSESSMENT CRITERIA

REASONABLE ACCOMODATIONS

## Assessment

Assessment for certification in chemistry is based on the aim, objectives and learning outcomes outlined in the syllabus. Chemistry will be examined at two levels: Ordinary Level and Higher Level. There are two assessment components:

- Written examination 80%
- Second component assessment 20%

Both components of assessment will reflect the relationship between practical work and the theoretical content of the syllabus.

## Assessment components

### Written examination

The written examination will examine the following  
Assessment of the report will be based on the following:

- knowledge and understanding—application of chemistry principles and concepts
- problem solving based on integration, analysis and evaluation of qualitative and quantitative information and data
- capacity to form reasonable and logical argument based on evidence—clarity and coherence in argument, management of ideas.

–The percentage of total marks allocated to this component is 80%

### General assessment criteria for the written examination

*A high level of achievement* in this component is characterised by a thorough knowledge and understanding of chemistry facts, principles, concepts and methods from the whole syllabus and with few significant omissions. Candidates consistently apply their knowledge and understanding of chemistry to problem solving in both familiar and new contexts. They accurately analyse and evaluate qualitative and quantitative data from different sources; manipulation of data will be almost flawless. Candidates present logical arguments and ideas which in are clearly based on evidence.

*A moderate level of achievement* in this component is characterised by a good knowledge and understanding of chemistry facts, principles, concepts and methods from many parts of the syllabus. Candidates apply their knowledge and understanding of chemistry to problem solving in familiar contexts and in some new contexts using appropriate scientific terminology. They carry out

adequate levels of analysis and evaluation on qualitative and quantitative data from different sources; much of their manipulation of data will be correct. Candidates present arguments and ideas which, in the main, are based on evidence.

*A low level of achievement* in this component is characterised by a limited knowledge and understanding of chemistry facts, principles, concepts and methods. Candidates select appropriate facts and principles to solve problems concerning familiar material using a limited range of scientific terminology. They carry out basic manipulation of data using straightforward mathematics. Candidates present some explanations based on evidence from familiar contexts, though they may include irrelevant material.

### Second component assessment

The second component assessment will assess students' abilities to conduct first- hand investigations and communicate information and understandings based on these investigations. The second component of assessment is made up of two parts.

	Description	Marks
Laboratory notebook	reports on mandatory activities authenticated by teacher	5%
Practical examination	short tasks; learners record data, observations and analysis on a task sheet which is marked externally	15%

The percentage of total marks allocated to the second component assessment is 20%

### Laboratory notebook

Students must complete the practical activities specified in the syllabus. Over the two years of the course each student is required to maintain a laboratory notebook, in which a record of these activities is kept. This record must be available for inspection. As part of the assessment, marks will be awarded on a pro rata basis for the satisfactory completion of the specified practical activities.

### Practical examination

The practical examination is a laboratory based practical paper focussing on the following experimental skills

- capacity to apply principles and skills of experimental investigation

- ability to critically analyse results making links to theoretical concepts
- management and control of data collection
- mechanical accuracy of scientific process skills— observation, measurement, graphical analysis.

Students will complete a series of short set tasks over a period of 90 minutes. The knowledge and theory of experimental skills are drawn from within the syllabus; the contexts for the setting of tasks are not bound by the syllabus content. Within unfamiliar contexts, students are told exactly what to do and how to do it. Students are required to follow instructions to collect data and make observations. They then use these data and observations to analyse, evaluate and make deductions. Students record their data, observations and deductions on a task sheet which is marked externally.

## General assessment criteria for the second component

*A high level of achievement* in this component is characterised by demonstration of a comprehensive range of manipulative techniques in experimental activities. Candidates make and record observations and measurements with a high level of accuracy and precision. In almost all cases candidates recognise and describe trends and patterns in data and use chemistry knowledge and understanding to account for inconsistencies and anomalies. Candidates accurately interpret and analyse experimentally derived data; manipulation of the data is almost flawless. In all cases, candidates link theoretical concepts to interpretation of experimental evidence. Candidates complete all of the prescribed practical activities carried out over the two years.

*A moderate level of achievement* in this component is characterised by demonstration of a good range of manipulative techniques in experimental activities. Candidates make and record observations and measurements with some accuracy and precision. In most cases candidates recognise and describe trends and patterns in data and in the main use chemistry knowledge and understanding to account for inconsistencies and anomalies. Candidates' interpretation and analysis of experimentally derived data is generally accurate; much of their manipulation of the data is correct. In some cases, candidates link theoretical concepts to interpretation of experimental evidence. Candidates complete most of the prescribed practical activities carried out over the two years.

*A low level of achievement* in this component is characterised by demonstration of a limited range of manipulative techniques in experimental activities. There may be evidence of inaccuracy in measurement and recording of observations. Candidates fail to recognise and generally do not account for inconsistencies and anomalies. They show limited ability to interpret and analyse experimentally derived data; there may be significant levels of error in the manipulation of data. Candidates do not link theoretical concepts to interpretation of experimental evidence. Candidates complete few or none of the prescribed practical activities carried out over the two years.



## Reasonable accommodations

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The scheme of Reasonable Accommodations is designed to assist candidates with special needs at the Certificate examinations. The term special needs applies to candidates who have physical/medical and/or specific learning difficulties.

Reasonable accommodations are designed to remove as far as possible the impact of a disability on a candidate's performance, so as he or she can demonstrate in an examination his or her level of achievement—they are not designed to compensate for a possible lack of achievement arising from a disability.

Applications for reasonable accommodations are considered within a published framework of principles (Expert Advisory Group Report, January 2000) and are submitted by the school which a candidate attends on prescribed application forms. Applications are normally invited one year in advance of the examination concerned.



An Chomhairle Náisiúnta Curaclaim agus Measúnachta  
National Council for Curriculum and Assessment

**NCCA**

National Council for Curriculum and Assessment

24 Merrion Square, Dublin 2

T: +353 1 661 7177

F: +353 1 661 7180

[info@ncca.ie](mailto:info@ncca.ie)

[www.ncca.ie](http://www.ncca.ie)

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