Chemistry

LEVEL 4	15 TCE CREDIT POINTS
COURSE CODE	CHM415115
COURSE SPAN	2015 — 2024
READING AND WRITING STANDARD	NO
MATHEMATICS STANDARD	YES
COMPUTERS AND INTERNET STANDARD	NO

This course was delivered in 2018. Use A-Z Courses to find the current version (if available).

Chemistry is the study of materials and substances, and the transformations they undergo through interactions and transfer of energy

Chemists can use an understanding of chemical structures and processes to adapt, control and manipulate systems to meet particular economic, environmental and social needs. This includes addressing the global challenges of climate change and security of water, food and energy supplies, and designing processes to maximise the efficient use of Earth's finite resources. Studying Chemistry provides a learner opportunity to explore key concepts, models and theories through active inquiry into phenomena and through contexts that exemplify the role of chemistry and chemists in society. The study of chemistry provides a foundation for undertaking investigations in a wide range of scientific fields and often provides the unifying link across interdisciplinary studies. Learners will become more informed citizens, able to use chemical knowledge to inform evidence-based decision-making and engage critically with contemporary scientific issues.

Rationale

Knowledge and understanding of science, scientific literacy and scientific methods are necessary for learners to develop skills to resolve questions about their natural and constructed world.

The purpose of science education is to develop scientific literacy, helping learners: to be interested in, and understand, the world around them; to engage in discourse about the scientific and technological aspects underlying global and local issues; to be sceptical and questioning of claims made by others about scientific matters; to be able to identify questions, draw evidence-based conclusions and discuss their validity; and to form opinions, that are reasoned and informed, about the environment, about their own health and well-being and about the role and impact of science on society.

Chemistry is the study of materials and substances, and the transformations they undergo through interactions and transfer of energy. Chemists can use an understanding of chemical structures and processes to adapt, control and manipulate systems to meet particular economic, environmental and social needs. This includes addressing the global challenges of climate change and security of water, food and energy supplies, and designing processes to maximise the efficient use of Earth's finite resources.

Studying Chemistry provides a learner opportunity to explore key concepts, models and theories through active inquiry into phenomena and through contexts that exemplify the role of chemistry and chemists in society. The study of Chemistry provides a foundation for undertaking investigations in a wide range of scientific fields and often provides the unifying link across interdisciplinary studies. Learners will become more informed citizens, able to use chemical knowledge to inform evidence-based decision-making and engage critically with contemporary scientific issues.

Aims

Chemistry aims to develop learners':

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

Learning Outcomes

On successful completion of this course, learners will be able to:

1. identify principles of chemistry concepts, models and theories, related to electrochemistry, thermochemistry, kinetics and equilibrium, and organic and inorganic matter
2. identify ways in which knowledge of chemistry interacts with social, economic, cultural and political considerations in a range of contexts
3. use chemistry principles, outlined in the course content, to identify and predict chemical phenomena
4. identify the uses and limitations of chemical knowledge in a range of contexts
5. analyse and interpret chemical data to draw valid conclusions
6. apply logical processes to solve quantitative chemical problems
7. have practical skills in the use of scientific techniques and equipment relating to chemistry
8. use scientific inquiry skills to develop, perform, interpret and evaluate chemistry experiments and their design
9. communicate chemistry understanding using qualitative and quantitative representations in appropriate representations and formats, following accepted conventions and terminology
10. have discriminating research skills
11. be self-directing; be able to plan their study; persevere to complete tasks and meet deadlines; have cooperative working skills related to the study of Chemistry.

Access

Learners are required to be able to work as directed in practical situations as potentially dangerous materials and equipment may be used in this course.

It is highly recommended that learners studying Chemistry have successfully completed Physical Sciences Level 3, and, as a minimum, have studied or are currently studying General Mathematics Level 3 or equivalent.

Pathways

Studying senior secondary Science provides learners with a suite of skills and understandings that are valuable to a wide range of further study pathways and careers. An understanding of chemistry is relevant to a range of careers, including those in forensic science, environmental science, engineering, medicine, pharmacy, health science and sports science. Additionally, chemistry knowledge is valuable in occupations that rely on an understanding of materials and their interactions, such as art, winemaking, agriculture and food technology. Studying Chemistry will provide a foundation to pursue tertiary studies in science or a related discipline.

Resource Requirements

This course requires a suitably equipped laboratory and resources to conduct experiments. Learners need to be able to access a wide range of reliable sources of information about the uses and applications of science within the wider community.

Refer to '*What can I take to my exam?*' for the current TASC Calculator Policy that refers to Level 3 courses.

Course Size And Complexity

This course has been assessed as having a complexity level of 4.

In general, courses at this level provide theoretical and practical knowledge and skills for specialised and/or skilled work and/or further learning, requiring:

- broad factual, technical and some theoretical knowledge of a specific area or a broad field of work and learning
- a broad range of cognitive, technical and communication skills to select and apply a range of methods, tools, materials and information to:
  - complete routine and non-routine activities
  - provide and transmit solutions to a variety of predictable and sometimes unpredictable problems
- application of knowledge and skills to demonstrate autonomy, judgement and limited responsibility in known or changing contexts and within established parameters.

This Level 4 course has a size value of 15.

Course Content

For the content areas of Chemistry, the three (3) interrelated strands - Science Inquiry Skills; Science as a Human Endeavour; and Science Understanding - build on students' learning in F-10 *Australian Curriculum: Science*. In the practice of science, the three strands are closely integrated: the work of scientists reflects the nature and development of science; it is built around scientific inquiry; and it seeks to respond to and influence society. These three strands will be integrated into the study of four (4) chemistry topics:

- Fundamental principles and theories of electrochemistry
- Principles of thermochemistry, kinetics and equilibrium
- Properties and reactions of organic and inorganic matter
- Application of logical processes to solve quantitative chemical problems.

Each chemistry topic is **compulsory**, however the order of delivery is not prescribed. These Chemistry topics relate directly to Criteria 5 – 8. Criteria 1 – 4 apply to all four topics of chemistry.

This course has a design time of 150 hours. It is recommended that approximately 40 hours be spent engaged in practical activities, including hands-on experiments and demonstrations.

SCIENCE INQUIRY SKILLS

- Identify, research, construct and refine questions for investigation, proposing mechanisms and predicting possible outcomes.
- Plan investigations, including the procedure to be followed, the materials required and the type and amount of primary and/or secondary data to be collected; observing risk assessments; and considering research ethics.
- Conduct investigations safely, competently and methodically for the collection of valid and reliable data.
- Use Système Internationale Units (SI), scientific notation, standard notation and significant figures.
- Represent data in meaningful and useful ways, including: using appropriate graphic representations; organising and processing data to identify trends, patterns and relationships; identifying sources of random and systematic error; identifying anomalous data; selecting, synthesising and using evidence to make and justify conclusions.
- Evaluate models; interpret a range of scientific texts and evaluate processes, claims and conclusions by considering the quality of available evidence; and use reasoning to construct scientific arguments.
- Select, construct and use appropriate representations, including balanced chemical equations, half-equations, equilibrium constants and expressions, oxidation numbers, standard electrode potentials, cell diagrams, physical, virtual, and graphical models of primary, secondary and tertiary structures, structural formulas, and systematic nomenclature (using IUPAC conventions), to communicate conceptual understanding, solve problems and make predictions.
- Select, use and interpret appropriate mathematical representations to solve problems and make predictions.
- Communicate information or findings to others through selecting and constructing appropriate language, nomenclature, genres and modes, including scientific reports.

SCIENCE AS A HUMAN ENDEAVOUR

- Science is a global enterprise that relies on clear communication, international conventions, peer review and reproducibility.
- Models and theories are contested and refined or replaced when new evidence challenges them, or when a new model or theory has greater explanatory power.
- Advances in science understanding in one field can influence other areas of science, technology and engineering.
- The acceptance of scientific knowledge can be influenced by the ethical, political, social, economic and cultural context in which it is considered.
- The use of scientific knowledge may have beneficial and/or harmful and/or unintended consequences.
- Science can be limited in its ability to provide definitive answers to public debate; there may be insufficient reliable data available, or interpretation of the data may be open to question.

Support materials only that illustrate some possible contexts for exploring *Science as a Human Endeavour* concepts in relation to *Science Understanding* content are found in Appendix 1.

SCIENCE UNDERSTANDING

Fundamental principles and theories of electrochemistry **(*Criterion 5*)**

Electrochemistry

- Oxidation can be modelled as the loss of electrons from a chemical species, and reduction can be modelled as the gain of electrons by a chemical species; these processes can be represented using half-equations:
  - define a redox reaction
  - use clues such as element çè compound
  - assign oxidation states for hydrogen and oxygen in compounds that include metal hydrides and peroxides
  - calculate oxidation states of elements in molecules, molecular ions and compounds
  - identify substances that are undergoing oxidation and reduction in a redox reaction
  - use the electrochemical series to identify oxidisers and reducers, and to predict whether a redox reaction will occur spontaneously
  - identify oxidisers and reducers by the oxidation states of the atoms that they contain
  - identify the strongest oxidiser or reducer from a group, for example, $\mathbf{IO_3^-}$, $\mathbf{I_2}$ and $\mathbf{I^-}$
  - balance redox reaction in the presence of hydrogen ions
  - construct half equations for oxidation and reduction using $\mathbf{H_2O}_{(l)}$, $\mathbf{H^-_{(aq)}}$ and electrons
  - write overall equations by adding half-equations.
- The ability of an atom to gain or lose electrons can be explained with reference to valence electrons, consideration of energy, and the overall stability of the atom, and can be predicted from the atom's position in the periodic table.
- The relative strength of oxidising and reducing agents can be determined; by comparing standard electrode potentials
  - use the electrochemical series to identify the strength of oxidisers and reducers.
- Electrochemical cells, including galvanic and electrolytic cells, consist of oxidation and reduction half-cells connected via an external circuit that allows electrons to move from the anode (oxidation site) to the cathode (reduction site):
  - apply terms associated with electrochemical cells including: electrodes, anode, cathode, electrolyte, salt bridge, porous barrier, anions, cations, internal circuit and external circuit
  - sketch labelled diagrams of galvanic cells (cells involving two metals in solutions of their ions)
  - predict the direction of movement of ions in the internal circuit and electrons in the external circuit
  - understand the role of the salt bridge or porous barrier in maintaining electroneutrality.
- Galvanic cells generate an electrical potential difference from a spontaneous redox reaction; they can be represented as cell diagrams including anode and cathode half-equations:
  - understand how an electrochemical cell can produce electrical energy
  - use chemical shorthand to represent a variety of electrochemical cells including cells composed of inert electrodes
  - adhere to conventions of writing anode on the left and cathode on the right.
- Cell potentials at standard conditions can be calculated from standard electrode potentials; these values can be used to compare cells constructed from different materials:
  - sketch and construct cells not composed of metals and solutions of their ions including cells with inert electrodes and electrolytes containing species with different oxidation states
  - identify the chemicals and materials required to construct a non-galvanic cell
  - understand how the electrochemical series was devised with reference to the hydrogen half cell
  - predict which electrode is the anode or cathode of an electrochemical cell
  - calculate the EMF of a cell under standard conditions, $\mathbf{E^0}$.
- Electrolytic cells use an external electrical potential difference to provide the energy to allow a non-spontaneous redox reaction to occur, and can be used in small-scale and industrial situations:
  - predict the products of electrolysis of molten salts
  - predict the products of electrolysis of aqueous solutions using inert electrodes or reactive electrodes
  - understand that anions containing elements in their maximum oxidation states (CO_3^{2-}, NO_3^-, SO_4^{2-}, HSO_4^-, PO_4^{3-}, HPO_4^{2-}, $H_2PO_4^-$) cannot be oxidised further
  - understand the possibility of competing reactions when the concentrations of species in the electrolyte are non-standard
  - use the electrochemical series to predict the products of electrolysis and understand the limitations of these predictions
  - understand the application of electrochemistry to the processes of electrorefining and electroplating
  - perform calculations to find the mass of products, the current or the time of electrolysis using Faraday's Laws.
- Corrosion is an electrochemical processes which can be modelled as a redox reaction:
  - *Corrosion*
    - understand how substances in the environment corrode metals through oxidation
  - *The physical properties of rust*
    - understand that steel has metallic bonding and that rust has ionic bonding
    - contrast the physical properties of steel and rust
    - understand why the volume occupied by a quantity of rust is much greater that the same amount of steel
  - *The electrochemical nature of rust*
    - understand the electrochemical nature of rusting and predict the likely sites of oxidation and reduction
    - understand why stresses increase the likelihood of anode formation
    - understand why cathodes tend to occur where the concentration of O_2 is highest

        - understand why a variation in the concentration of O_2 can lead to the formation of an electrochemical cell
        - understand the role of dissolved ions in accelerating corrosion
        - predict which metal will be the anode and which will be the cathode when two metals are in contact with an electrolyte
    - *Corrosion prevention*
        - compare ways in which corrosion can be prevented by excluding the environment including: painting, lubrication, metal coatings (noble and sacrificial), cathodic protection (sacrificial anodes and applied EMF) and polymer coatings.

Principles of thermochemistry, kinetics and equilibrium **(*Criterion 6*)**

Thermochemistry

- Heat content and enthalpy:
    - understand the concepts of heat content and enthalpy for chemical reactions.
- Energy in chemical reactions:
    - understand that forming bonds releases, and that breaking bonds absorbs energy
    - recall that exothermic reactions release energy and endothermic reactions absorb heat energy
    - construct enthalpy/potential energy diagrams including activation energy.
- Thermochemical equations:
    - write the heat of reaction as a reactant or product or write thermochemical equations using ΔH notation, and kJ for the reaction.
- Heat energy calculations:
    - calculate the heat energy released or absorbed during a chemical reaction for a known mass or reactant or product.
- Calorimetry:
    - calibrate a calorimeter
    - calculate the heat energy involved when a known mass of substance undergoes a measured change in temperature

      $E_H = mc\Delta T$
    - calculate the heat energy required for a known mass of substance to undergo a change in state from solid to liquid or from liquid to gas
    - use the techniques of calorimetry to measure the heat of reaction.
- Bond energy:
    - define bond energy
    - identify the bonds that must be broken and formed in the course of a chemical reaction and calculate the heat of reaction using a table of bond energies.
- Hess' Law:
    - use Hess' Law of the additivity of heats of reaction to calculate ΔH for unknown reactions by summing thermochemical equations.

Kinetics

- Reaction rate:
    - define the reaction rate as the rate at which product is produced or the rate at which a reactant is consumed
    - find the average rate by dividing the change in the amount of product by the time taken: $\textbf{average rate} = \frac{\Delta n_{\text{product}}}{t}$
    - find the average rate by dividing the change in the concentration of product by the time taken: $\textbf{average rate} = \frac{\Delta c_{\text{product}}}{t}$.
- Factors affecting the rate:
    - use the collision theory to explain the expected changes in rates of reactions:
        - concentration of reactants (pressure for gases)
        - surface area over which the reactants are in contact

        - temperature of reactants
        - nature of reactants i.e. more bonds to be broken the slower the reaction rate, complexity of the reaction (e.g. precipitation)
        - presence of a catalyst.
- Temperature:
    - construct a diagram to show the distribution of kinetic energy for molecules at a particular temperature
    - understand how the increase in reaction rate with temperature is related to the increase in the proportion of molecules with sufficient kinetic energy to react.
- Catalysts:
    - construct a potential energy diagram for a reaction to show the effect of a catalyst on the activation energy due to a different reaction pathway
    - understand that one example of a catalyst is an enzyme which is a biological catalyst.

Chemical Equilibrium

- Chemical systems may be open or closed and include physical changes and chemical reactions that can result in observable changes to the system.
- All physical changes are reversible, whereas only some chemical reactions are reversible:
    - understand that not all reactions go to completion and that products may be converted back to reactants
    - understand that an equilibrium state represents a compromise (or balance) between the two naturally occurring driving forces towards minimum enthalpy and maximum entropy.
- Over time, physical changes and reversible chemical reactions reach a state of dynamic equilibrium in a closed system, with the relative concentrations of products and reactants defining the position of equilibrium:
    - recognise that equilibrium has been reached if there are significant amounts of products and reactants present with no discernible change to their concentrations over time
    - understand that at equilibrium the rate of the forward and reverse reactions are equal.
- The reversibility of chemical reactions can be explained by considering the activation energies of the forward and reverse reactions.
- The effect of changes of temperature on chemical systems at equilibrium can be explained by considering the enthalpy changes for the forward and reverse reactions.
- The effects of changing the conditions of a system at equilibrium may be predicted by considering the effect on the rates of competing reactions, for example:
    - changing the concentration of a species in solution
    - adding a catalyst
    - changing the volume of a container of gaseous reactants and products
    - changing the partial pressure of one gaseous reactant
    - adding an inert substance.
- The effects of changes of temperature, concentration of chemicals and pressure on equilibrium systems can be predicted using Le Chatelier’s Principle.
- Le Chatelier’s principle has limitations in its application.
- Equilibrium position can be predicted using equilibrium constants:
    - recall the law of equilibrium and recognise that it is a consequence of the competing reactions having equal rates
    - define the equilibrium constant for a reaction based on the coefficients of reactants and products
    - realise that concentrations of pure substances are incorporated into K
    - recognise that the size of the equilibrium constant is a measure of the extent to which a reaction goes to completion
    - perform calculations on the concentrations of reactants or products using equilibrium constants
    - understand that the value of the reaction quotient (Q) indicates the direction in which a reacting system will move so as to establish equilibrium.
- Acids are substances that can act as proton (hydrogen ion) donors and can be classified as monoprotic or polyprotic depending on the number of protons donated by each molecule of the acid. Bases are substances that can act as a proton (hydrogen) acceptors.
- The strength of acids is explained by the degree of ionisation at equilibrium in aqueous solution, which can be represented with chemical equations and equilibrium constants (K_a):
    - understand ionisation of strong and weak acids in aqueous solutions
    - define K_a for a monoprotic acid
    - understand that in aqueous solutions: $\mathrm{K}_w = \left[\mathrm{H}^+_{(aq)}\right]\left[\mathrm{OH}^-_{(aq)}\right] = 10^{-14}$ at $25^\circ\ \mathrm{C}$.
- The relationship between acids and bases in equilibrium systems can be explained using the Brønsted-Lowry model and represented using chemical equations that illustrate the transfer of hydrogen ions (or hydronium ions).

- The pH scale is a logarithmic scale and the pH of a solution can be calculated from the concentration of hydrogen ions:
    - use K_w to calculate the concentration of hydrogen ions from the concentration of hydroxide ions in a solution
    - calculate the pH of known concentrations of strong monoprotic acids
    - calculate the pH of known concentrations of weak monoprotic acids
    - calculate the pH of solutions of strong bases.

***Properties and reactions of organic and inorganic matter* (*Criterion 7*)**

Gases

- Properties of Gases:
    - understand the properties of gases as described by Boyle's Law, Charles' Law and the ideal gas equation
    - understand how the kinetic theory of matter explains these properties, including gas mixtures and non-ideal behaviours of real gases.

Properties and Structures of Organic Materials

- Organic molecules have a hydrocarbon skeleton and can contain functional groups, including alkyl halides, alcohols, carboxylic acids, and esters:
    - define a functional group
    - name and draw structural formulae of organic molecules including those with functional groups (amines and amides – simple only)
    - understand that amino acids, the building units for proteins, are organic acids with an amine group attached to a hydrocarbon chain containing an acid ($-\mathrm{COOH}$) group.
- Each class of organic compounds displays characteristic physical and chemical properties, and undergoes specific reactions, based on the functional groups present. These reactions include addition, substitution, acid-base and oxidation reactions. The organic compounds will be limited to only 2 functional groups for external assessment.
- Properties and reactions of alkyl halides:
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    - compare the physical properties of alkyl halides with the alkanes from which they were made. Relate these to polarity, dipole-dipole forces and dispersion forces.
    - alkyl halides undergo substitution reactions more readily that the alkanes from which they were synthesised
    - write equations for the reactions of alkyl halides to form primary, secondary and tertiary alcohols.
- Understand the structure of benzene – a flat, symmetrical ring structure, with the bonds between carbon atoms being intermediate between single and double bonds. The resulting molecule is very stable with all carbon bonds being of the same length. Because the benzene ring is so widely found in both artificially synthesised and natural organic compounds, the individual C and H atoms are not written out in full. The most common structural formula is written as a hexagon with a circle within it.
- Properties and reactions of alcohols:
    - understand why the presence of hydrogen bonding leads to an increase in melting and boiling points compared to the corresponding alkanes
    - hydrogen bonding also tends to make the alcohols more soluble than the corresponding alkanes in polar solvents such as water
    - distinguish between primary, secondary and tertiary alcohols
    - understand why polyalcohols have much higher boiling points than the corresponding simple alcohols
    - write equations for the reactions of alcohols with sodium metal and carboxylic acids
    - write equations for the oxidation of primary alcohols to form aldehydes when heated in the presence of copper catalysts or when treated with limited acidified dichromate solution
    - write equations for the oxidation of primary alcohols by stronger oxidisers such as acidified permanganate solution
    - write equations for the oxidation of secondary alcohols to produce ketones
    - understand why tertiary alcohols do not undergo oxidation reactions.
- Organic molecules including polymers, can be synthesised using addition, substitution and condensation reactions:
    - compare the reactions of alkanes and alkenes, with halogens:
        - understand how alkane compounds undergo substitution reactions
        - write combustion reactions for hydrocarbons reacting with an excess of oxygen and reactions where there is insufficient oxygen
        - understand how alkenes and alkynes undergo addition reactions
    - write equations for the complete reactions of alkenes and alkynes with asymmetric molecules, including hydrogen halides and steam
    - identify the possible isomers resulting from an asymmetric molecule reacting with an unsaturated hydrocarbon
    - describe how alkenes form addition polymers
    - describe how polyesters are formed from polyalcohols and polyacids.
- Properties and reactions of aldehydes and ketones:

    - write equations for the oxidation of aldehydes to produce carboxylic acids
    - understand why aldehydes tend to be less soluble in polar solvents than the alcohols from which they were synthesised
    - understand why ketones cannot be oxidised further.
- Properties and reactions of carboxylic acids:
    - understand that carboxylic acids are weak acids
    - define carboxylic acids as monoacids or polyacids
    - recognise that the pH of solutions of carboxylic acids tends to be higher than for solutions of strong acids with the same concentration
    - write equations for the reactions of carboxylic acids with carbonates, sodium hydrogen carbonate, metal oxides and hydroxides, reactive metals and alkaline solutions
    - write equations for the reactions of carboxylic acids with primary alcohols to form esters.
- Understand that fuels can be synthesised from organic or sources using a range of chemical reactions including addition, oxidation and esterification (brief treatment only).
- Properties and reactions of esters:
    - understand that esters tend to be insoluble in water and have distinctive smells
    - write equations for the hydrolysis of esters, including alkaline hydrolysis.
- Properties and reactions of **simple** amines and amides:
    - the presence of hydrogen bonding leads to an increase in melting and boiling points compared to the corresponding alkanes
    - hydrogen bonding also tends to make the amines and amides more soluble than the corresponding alkanes in polar solvents such as water.
- The structure of organic molecules can be determined using spectroscopic and instrumental analytical techniques as follows:
    - mass spectroscopy, including the determination of the molecular ion peak, relative molecular mass and identification of simple molecular fragments
    - Infra-red (IR) spectroscopy, including use of characteristic absorption bands to identify some functional groups
    - X-ray crystallography to identify simple molecular structures,

  and often requires evidence from more than one technique.

(New content not studied in CHM315114 - excludes features of instrumentation and operation.)

The Periodic Table

- Evidence for shells of electrons:
    - understand the variation of ionisation energy as successive electrons are removed
    - understand the principles of emission and absorption spectra (qualitative only).
- The Bohr model of the atom:
    - describe the Bohr model of the hydrogen atom
    - understand the difference between shells, sub-shells and orbitals (mention quantum numbers).
- Electron configurations:
    - write the electron configuration for atoms and simple ions in their ground states using sub-shells (*s*, p and *d* only)
    - define and apply the term isoelectronic
    - predict the charges of ions formed from the main groups of the Periodic Table (not including transition metal elements).
- Valence Theory:
    - apply understanding of atomic number and electron configurations to explain the periodic variation of chemical properties (not including transition metal elements)
    - use valence theory to explain the periodic variations of the chemical properties of the *s* and *p* block elements, and explains the trends and anomalies in the behaviour of elements.
- Trends in the Periodic Table:
    - identify and explain the trends in the behaviour across periods and within groups using terms such as electronegativity, core charge and nuclear shielding
    - understand why metals in the main groups get less reactive, and non-metals get more reactive, from left to right in the Periodic Table (not including transition metal elements)
    - understand why metals get more reactive and non-metals get less reactive descending the Periodic Table
    - understand changes in atomic and ionic radii in the Periodic Table.
- Mass spectroscopy is a method used to analyse isotopic mixtures. (New content not studied in CHM315114.)

***Application of logical processes to solve quantitative chemical problems* (*Criterion 8*)**

Chemical Stoichiometry

- Principles of chemical reactions and reacting quantities:
  - review all reactions and calculations included in Physical Sciences Level 3: Criteria 7 & 8.
- Mass calculations:
  - calculate the masses of a reactant and/or product when reactions go to completion.
- Gravimetric analysis:
  - calculate the mass of product formed as a result of a precipitation reaction
  - calculate the %-purity and %-yield of a reaction product
  - calculate water of crystallisation of a hydrated compound.
- Mass-volume calculations:
  - describe the properties of primary standard substances
  - calculations involving the preparation of primary standard solutions
  - calculate the concentration of a solution after dilution.
- Limiting reagents:
  - identify the limiting reagent when the mass/concentration and volume of more than one reactant are known
  - calculate the mass/concentration/volume of a reactant and/or product when one of the reactants is identified as the limiting reagent.
- Volumetric analysis methods involving acid-base reactions rely on the identification of an equivalence point. This is observed by measuring the associated change in pH, using chemical indicators or pH meters. Acid-base indicators are weak acids or bases where the acidic form is of a different colour to the basic form:
  - perform calculations related to acid-base titrations
  - perform calculations related to redox titrations
  - calculate the concentrations of unknown solutions by using the data collected from volumetric analysis.
- Chemical synthesis (New content not studied in CHM315114.):
  - chemical synthesis involves the selection of particular reagents to form a product with specific properties (for example, pharmaceuticals, fuels, cosmetics, cleaning products)
  - design chemical synthesis processes includes identifying reagents and reaction conditions in order to maximise yield and purity of product
  - calculate the yield of a chemical synthesis reaction by comparing stoichiometric quantities with actual quantities.
- Gases:
  - perform calculations associated with the gas laws, including finding the molar volume of an ideal gas, convert temperature to absolute temperature and vice versa
  - be familiar with the molar volume of ideal gases at standard temperature and pressure (STP) and under standard laboratory conditions (SLC) for gases collected over vapour pressure equilibrium
  - perform calculations involving use of combined gas and ideal gas equations.
- Other calculations:
  - Criteria 5, 6 and 7 calculations are examined externally as part of criterion 8, for example, Faraday's Laws of Electrolysis.

Assessment

Criterion-based assessment is a form of outcomes assessment that identifies the extent of learner achievement at an appropriate end-point of study. Although assessment – as part of the learning program – is continuous, much of it is formative, and is done to help learners identify what they need to do to attain the maximum benefit from their study of the course. Therefore, assessment for summative reporting to TASC will focus on what both teacher and learner understand to reflect end-point achievement.

The standard of achievement each learner attains on each criterion is recorded as a rating 'A', 'B', or 'C', according to the outcomes specified in the standards section of the course.

A 't' notation must be used where a learner demonstrates any achievement against a criterion less than the standard specified for the 'C' rating.

A 'z' notation is to be used where a learner provides no evidence of achievement at all.

Providers offering this course must participate in quality assurance processes specified by TASC to ensure provider validity and comparability of standards across all awards. To learn more, see TASC's quality assurance processes and assessment information.

Internal assessment of all criteria will be made by the provider. Providers will report the learner's rating for each criterion to TASC.

TASC will supervise the external assessment of designated criteria which will be indicated by an asterisk (*). The ratings obtained from the external assessments will be used in addition to internal ratings from the provider to determine the final award.

Quality Assurance Process

The following processes will be facilitated by TASC to ensure there is:

- a match between the standards of achievement specified in the course and the skills and knowledge demonstrated by learners
- community confidence in the integrity and meaning of the qualification.

Process – TASC gives course providers feedback about any systematic differences in the relationship of their internal and external assessments and, where appropriate, seeks further evidence through audit and requires corrective action in the future.

External Assessment Requirements

The external assessment for this course will comprise:

- a written examination assessing criteria: 5, 6, 7 and 8.

For further information see the current external assessment specifications and guidelines for this course available in the Supporting Documents below.

Criteria

The assessment for Chemistry Level 4 will be based on the degree to which the learner can:

1. demonstrate personal skills to plan, organise and complete activities
2. develop, interpret and evaluate chemistry experiments
3. collect, process and communicate information
4. demonstrate understanding of the application and impact of chemistry in society
5. identify and apply fundamental principles and theories of electrochemistry*
6. identify and apply principles and theories of thermochemistry, kinetics and equilibrium*
7. demonstrate knowledge and understanding of properties and reactions of organic and inorganic matter*
8. apply logical processes to solve quantitative chemical problems*

* = denotes criteria that are both internally and externally assessed

Standards

Criterion 1: demonstrate personal skills to plan, organise and complete activities

The learner:

Rating A	Rating B	Rating C
uses techniques and equipment related to chemistry safely, competently and methodically, applying them to unfamiliar contexts	uses techniques and equipment related to chemistry safely, competently and methodically	uses familiar techniques and equipment related to chemistry safely and competently
follows instructions accurately and methodically, adapting to new circumstances	follows instructions accurately and methodically to complete the task	follows instructions accurately to complete the task
monitors and critically evaluates progress towards meeting goals and timelines and plans future actions	monitors and analyses progress towards meeting goals and timelines and plans future actions	monitors progress towards meeting goals and timelines
performs tasks, modifies own contribution and guides others in their contribution to the successful completion of group activities.	performs tasks and modifies own contribution to the successful completion of group activities.	performs tasks to effectively contribute to the completion of group activities.

Criterion 2: develop, interpret and evaluate chemistry experiments

Related to the study of Chemistry, the learner:

Rating A	Rating B	Rating C
expresses a plausible and readily testable scientific idea that explains all experimental observations	expresses a plausible scientific idea that explains all experimental observations	expresses a scientific idea that explains some experimental observations
critically analyses and interprets data to draw a valid conclusion that relates to the purpose of the experiment	analyses and interprets data to draw a valid conclusion that relates to the purpose of the experiment	based on experimental results, draws a conclusion that relates to the purpose of the experiment and has some validity
discusses significant limitations and sources of error in experimental design, with reference to theory and/or evidence	identifies significant limitations and sources of error in an experimental design	identifies some limitations and sources of error in an experimental design
critically evaluates an experimental design and provides an evidence-based critique and discussion on valid improvements and alternatives.	analyses an experimental design and describes a number of possible valid improvements.	identifies a valid improvement in an experimental design.

Criterion 3: collect, process and communicate information

The learner:

Rating A	Rating B	Rating C
uses a variety of relevant resources to collect information, and critically evaluates their reliability	uses a variety of relevant resources to collect information, and evaluates their reliability	uses a variety of relevant resources to collect information
collects a wide range of appropriate experimental data, and records it	collects adequate experimental data and records it suitably	collects and records experimental data

methodically for analysis		
clearly identifies the information, images, ideas and words of others used in the learner's work	clearly identifies the information, images, ideas and words of others used in the learner's work	differentiates the information, images, ideas and words of others from the learner's own
clearly identifies sources of the information, images, ideas and words that are not the learner's own. Referencing conventions and methodologies are followed with a high degree of accuracy.	clearly identifies sources of the information, images, ideas and words that are not the learner's own. Referencing conventions and methodologies are followed correctly.	identifies the sources of information, images, ideas and words that are not the learner's own. Referencing conventions and methodologies are generally followed correctly.
creates appropriate, well structured reference lists/bibliographies	creates appropriate, structured reference lists/bibliographies	creates appropriate reference lists/bibliographies
selects and uses appropriate scientific formats for effective and accurate communication of information for specific audiences and purposes.	uses an appropriate scientific format for clear and accurate communication of information for specific audiences and purposes.	uses an appropriate scientific format for communication of information.

Criterion 4: demonstrate understanding of the application and impact of chemistry in society

Related to the study of Chemistry, the learner:

Rating A	Rating B	Rating C
explains the relevance of identified science background to an issue	describes relevant science background to an issue	identifies relevant science background to an issue
explains significant components of an issue, and presents a detailed and balanced discussion	describes components of an issue, and presents a balanced discussion	identifies key components of an issue, and presents a considered discussion
clearly describes and critically evaluates the tensions and connections between an issue and all significant relevant influences (ethical, political, cultural, social, economic)	clearly describes the tensions and connections between an issue and most of the relevant influences (ethical, political, cultural, social, economic)	identifies connections between an issue and some of the relevant influences (ethical, political, cultural, social, economic)
analyses and evaluates to present a complex argument related to the benefits of the use of scientific knowledge, and any harmful or unintended consequences	describes the benefits of the use of scientific knowledge, and any harmful or unintended consequences	identifies the benefits of the use of scientific knowledge, and any harmful or unintended consequences
argues a reasoned conclusion, linking it to relevant evidence. Assesses the impact of the application of the decision in society.	argues a reasoned conclusion, articulating links to relevant evidence.	presents a reasoned conclusion, using some relevant evidence.

Criterion 5: identify and apply fundamental principles and theories of electrochemistry

This criterion is both internally and externally assessed.

The learner:

Rating A	Rating B	Rating C
explains fundamental principles and theories related to electrochemistry	describes fundamental principles and theories related to electrochemistry	identifies fundamental principles and theories related to electrochemistry

given the species, constructs half-equations to balance complex redox equations, and predicts the reactions occurring between oxidisers and reducers	given the species, constructs half-equations to balance redox equations, and predicts the reactions occurring between oxidisers and reducers	uses given half-equations to balance redox equations, and identifies the reactions occurring between oxidisers and reducers
uses the electrochemical series to predict the reactions that occur when more than two species are present under standard conditions, and suggests why some variations are observed	uses the electrochemical series to predict the reactions that occur when more than two species are present under standard conditions	uses the electrochemical series to predict the reactions between two species under standard conditions
draws a cell diagram showing the movement of ions and electrons, and writes half-equations for the reactions at each electrode, in unfamiliar electrochemical and electrolytic cells	draws a cell diagram showing the movement of ions and electrons, and writes half-equations for the reactions at each electrode, in familiar electrochemical and electrolytic cells	draws a cell diagram and writes half-equations for the reactions at each electrode in familiar electrochemical and electrolytic cells
explains the chemical processes associated with the corrosion of metals; describes two or more methods that could be used to prevent it; and identifies the most appropriate method for prevention.	describes the chemical processes associated with the corrosion of metals, and describes two or more methods that could be used to prevent it.	identifies the chemical processes associated with the corrosion of steel, and describes a method to prevent it.

Criterion 6: identify and apply principles and theories of thermochemistry, kinetics and equilibrium

This criterion is both internally and externally assessed.

The learner:

Rating A	Rating B	Rating C
explains fundamental principles and theories related to thermochemistry, kinetics and equilibrium	describes fundamental principles and theories related to thermochemistry, kinetics and equilibrium	identifies fundamental principles and theories related to thermochemistry, kinetics and equilibrium
constructs and analyses energy diagrams and explains that the enthalpy of reaction is the result of making and breaking of bonds	constructs and uses energy diagrams to explain that the enthalpy of reaction is the result of making and breaking of bonds	constructs and identifies key features of energy diagrams
predicts and explains variation in reaction rates using collision theory and the concepts of catalysis and the distribution of energy	explains variation in reaction rates using collision theory and the concepts of catalysis and the distribution of energy	discusses variation in reaction rates using collision theory and the concept of catalysis
identifies a system at equilibrium, and predicts and explains the effects of changes to the system, stating the limitations of Le Chatelier's principle	identifies a system at equilibrium, and predicts and explains the effects of changes to the system	identifies a system at equilibrium, and predicts the effects of changes to the system
performs complex calculations associated with thermochemistry, reaction rates and equilibrium.	performs calculations associated with thermochemistry, reaction rates and equilibrium.	performs routine calculations associated with thermochemistry, reaction rates and equilibrium.

Criterion 7: demonstrate knowledge and understanding of properties and reactions of organic and inorganic matter

This criterion is both internally and externally assessed.

The learner:

Rating A	Rating B	Rating C
draws and names organic molecules, including simple aliphatic molecules with more than one functional group, isomeric variations and addition and condensation polymers	draws and names organic molecules, including simple aliphatic molecules with more than one functional group	draws and names organic molecules, including simple aliphatic molecules with one functional group
uses the concept of bond polarity to analyse variations in the physical properties of organic molecules containing different functional groups, and uses these properties and data from analytical techniques to identify functional groups	uses the concept of bond polarity to explain variations in the physical properties of organic molecules containing different functional groups, and uses these properties and data from analytical techniques to identify functional groups	identifies variations in the physical and chemical properties of organic molecules containing different functional groups, and uses these properties and data from analytical techniques to identify functional groups
writes equations for reactions of organic molecules with a range of functional groups and reagents	writes equations for reactions of organic molecules with a range of functional groups	writes equations for common reactions of organic molecules with a limited range of functional groups
writes electron configurations for elements using sub-shells to make predictions about chemical activity in unfamiliar contexts	writes electron configurations for elements using sub-shells to make predictions about chemical activity in familiar contexts	writes electron configurations for elements using sub-shells, and predicts the charges of ions from the main groups of the Periodic Table
uses valence theory to explain the periodic variations of the chemical properties of the s and p block elements, and explains the trends and anomalies in the behaviour of elements	uses valence theory to describe the periodic variations of the chemical properties of the s and p block elements, and discusses the trends in the behaviour of elements	uses valence theory to identify the periodic variation of the chemical properties of the s and p block elements, and identifies the trends in the behaviour of elements
explains observed behaviours of gases, including gas mixtures and non-ideal behaviours of real gases, using the Kinetic Molecular Theory, and applies the gas laws and gas equations to relevant situations.	describes observed behaviours of gases, including gas mixtures, using the Kinetic Molecular Theory, and applies the gas laws and gas equations to relevant situations.	identifies observed behaviours of gases using the Kinetic Molecular Theory, and applies the gas laws and gas equations to relevant situations.

Criterion 8: apply logical processes to solve quantitative chemical problems

This criterion is both internally and externally assessed.

The learner:

Rating A	Rating B	Rating C
performs organic and inorganic stoichiometric calculations associated with volumetric analysis, including acid-base and redox titrations with unfamiliar reactants	performs organic and inorganic stoichiometric calculations associated with volumetric analysis, including acid-base and redox titrations with familiar reactants	performs routine organic and inorganic stoichiometric calculations associated with volumetric analysis for familiar organic and inorganic chemistry
performs complex stoichiometric calculations to find the mass or volume of reactants or products, including gases and solutions and limiting quantities	performs stoichiometric calculations to find the mass or volume of reactants or products, including gases and solutions, and limiting quantities	performs routine stoichiometric calculations to find the mass or volume of reactants or products, including gases
performs calculations associated with electrochemistry in complex systems	performs calculations associated with electrochemistry	performs routine calculations associated with electrochemistry
performs calculations associated with thermochemistry, kinetics and equilibrium (including acid-base equilibrium) and recognises their limitations.	performs calculations associated with thermochemistry, kinetics and equilibrium (including acid-base equilibrium).	performs routine calculations associated with thermochemistry, kinetics and equilibrium (including acid-base equilibrium).

Qualifications Available

Chemistry Level 4 (with the award of):

EXCEPTIONAL ACHIEVEMENT

HIGH ACHIEVEMENT

COMMENDABLE ACHIEVEMENT

SATISFACTORY ACHIEVEMENT

PRELIMINARY ACHIEVEMENT

Award Requirements

The final award will be determined by the Office of Tasmanian Assessment, Standards and Certification from 12 ratings (8 from the internal assessment, 4 from the external assessment).

The minimum requirements for an award in Chemistry Level 4 are as follows:

EXCEPTIONAL ACHIEVEMENT (EA)
10 ‘A’ ratings, 2 ‘B’ ratings (3 ‘A’ ratings, 1 ‘B’ rating from external assessment)

HIGH ACHIEVEMENT (HA)
4 ‘A’ ratings, 5 ‘B’ ratings, 3 ‘C’ ratings (1 ‘A’ rating, 2 ‘B’ ratings and 1 ‘C’ rating from external assessment)

COMMENDABLE ACHIEVEMENT (CA)
6 ‘B’ ratings, 5 ‘C’ ratings (2 ‘B’ ratings, 2 ‘C’ ratings from external assessment)

SATISFACTORY ACHIEVEMENT (SA)
10 ‘C’ ratings (3 ‘C’ ratings from external assessment)

PRELIMINARY ACHIEVEMENT (PA)
6 ‘C’ ratings

A learner who otherwise achieves the ratings for a CA (Commendable Achievement) or SA (Satisfactory Achievement) award but who fails to show any evidence of achievement in one or more criteria (‘z’ notation) will be issued with a PA (Preliminary Achievement) award.

Course Evaluation

The Department of Education’s Curriculum Services will develop and regularly revise the curriculum. This evaluation will be informed by the experience of the course’s implementation, delivery and assessment.

In addition, stakeholders may request Curriculum Services to review a particular aspect of an accredited course.

Requests for amendments to an accredited course will be forwarded by Curriculum Services to the Office of TASC for formal consideration.

Such requests for amendment will be considered in terms of the likely improvements to the outcomes for learners, possible consequences for delivery and assessment of the course, and alignment with Australian Curriculum materials.

A course is formally analysed prior to the expiry of its accreditation as part of the process to develop specifications to guide the development of any replacement course.

Expectations Defined By National Standards In Content Statements Developed by ACARA

The statements in this section, taken from *Australian Senior Secondary Curriculum: Chemistry* endorsed by Education Ministers as the agreed and common base for course development, are to be used to define expectations for the meaning (nature, scope and level of demand) of relevant aspects of the sections in this document setting out course requirements, learning outcomes, the course content and standards in the assessment.

Unit 1 – Properties and structures of atoms

- Trends in the observable properties of elements are evident in periods and groups in the periodic table. (ACSCH016)
- The structure of the periodic table is based on the electron configuration of atoms, and shows trends, including in atomic radii and valencies. (ACSCH017)
- Atoms can be modelled as a nucleus surrounded by electrons in distinct energy levels, held together by electrostatic forces of attraction between the nucleus and electrons; atoms can be represented using electron shell diagrams (all electron shells or valence shell only) or electron charge clouds. (ACSCH018)

Unit 2 – Rates of Chemical Reactions

- Varying the conditions present during chemical reactions can affect the rate of the reaction and in some cases the identity of the products. (ACSCH068)
- The rate of chemical reactions can be quantified by measuring the rate of formation of products or the depletion of reactants. (ACSCH069)
- Collision theory can be used to explain and predict the effect of concentration, temperature, pressure and surface area on the rate of chemical reactions by considering the structure of the reactants and the energy of particles. (ACSCH070)
- The activation energy is the minimum energy required for a chemical reaction to occur and is related to the strength of the existing chemical bonds; the magnitude of the activation energy influences the rate of a chemical reaction. (ACSCH071)
- Energy profile diagrams can be used to represent the enthalpy changes and activation energy associated with a chemical reaction. (ACSCH072)
- Catalysts (.........) affect the rate of certain reactions by providing an alternative reaction pathway with a reduced activation energy, hence increasing the proportion of collisions that lead to a chemical change. (ACSCH073)

Unit 3 – Chemical equilibrium systems

- Chemical systems may be open or closed and include physical changes and chemical reactions that can result in observable changes to the system. (ACSCH089)
- All physical changes are reversible, whereas only some chemical reactions are reversible. (ACSCH090)
- Over time, physical changes and reversible chemical reactions reach a state of dynamic equilibrium in a closed system, with the relative concentrations of products and reactants defining the position of equilibrium. (ACSCH091)
- The reversibility of chemical reactions can be explained by considering the activation energies of the forward and reverse reactions. (ACSCH092)
- The effect of changes of temperature on chemical systems at equilibrium can be explained by considering the enthalpy changes for the forward and reverse reactions. (ACSCH093)
- The effect of changes of concentration and pressure on chemical systems at equilibrium can be explained and predicted by applying collision theory to the forward and reverse reactions. (ACSCH094)
- The effects of changes of temperature, concentration of chemicals and pressure on equilibrium systems can be predicted using Le Chatelier's Principle. (ACSCH095)
- Equilibrium position can be predicted (quantitatively) using equilibrium constants. (ACSCH096)
- Acids are substances that can act as proton (hydrogen ion) donors and can be classified as monoprotic or polyprotic depending on the number of protons donated by each molecule of the acid. (ACSCH097)
- The strength of acids is explained by the degree of ionisation at equilibrium in aqueous solution, that can be represented with chemical equations and equilibrium constants (K_a). (ACSCH098)
- The relationship between acids and bases in equilibrium systems can be explained using the Brønsted-Lowry model and represented using chemical equations that illustrate the transfer of hydrogen ions. (ACSCH099)
- The pH scale is a logarithmic scale and the pH of a solution can be calculated from the concentration of hydrogen ions; Kw can be used to calculate the concentration of hydrogen ions from the concentration of hydroxide ions in a solution. (ACSCH100)
- Acid-base indicators are weak acids or bases where the acidic form is of a different colour to the basic form. (ACSCH101)
- Volumetric analysis methods involving acid-base reactions rely on the identification of an equivalence point by measuring the associated change in pH, using chemical indicators or pH meters, to reveal an observable end point. (ACSCH102)

Unit 3 – Oxidation and reduction

- A range of reactions, including displacement reactions of metals, combustion, corrosion, and electrochemical processes, can be modelled as redox reactions involving oxidation of one substance and reduction of another substance. (ACSCH103)
- Oxidation can be modelled as the loss of electrons from a chemical species, and reduction can be modelled as the gain of electrons by a chemical species; these processes can be represented using half-equations. (ACSCH104)
- The ability of an atom to gain or lose electrons can be explained with reference to valence electrons, consideration of energy, and the overall stability of the atom, and can be predicted from the atom's position in the periodic table. (ACSCH105)
- The relative strength of oxidising and reducing agents can be determined by comparing standard electrode potentials. (ACSCH106)
- Electrochemical cells, including galvanic and electrolytic cells, consist of oxidation and reduction half-reactions connected via an external circuit that allows electrons to move from the anode (oxidation reaction) to the cathode (reduction reaction). (ACSCH107)
- Galvanic cells, including fuel cells, generate an electrical potential difference from a spontaneous redox reaction; they can be represented as cell diagrams including anode and cathode half-equations. (ACSCH108)
- Fuel cells can use metal nanoparticles as catalysts to improve the efficiency of energy production. (ACSCH109)
- Cell potentials at standard conditions can be calculated from standard electrode potentials; these values can be used to compare cells constructed from different materials. (ACSCH110)
- Electrolytic cells use an external electrical potential difference to provide the energy to allow a non-spontaneous redox reaction to occur, and can be used in small-scale and industrial situations. (ACSCH111)

Unit 4 – Properties and structure of organic materials

- Organic molecules have a hydrocarbon skeleton and can contain functional groups, including alcohols, carboxylic acids, esters, amines and amides. (ACSCH127)
- Each class of organic compounds displays characteristic chemical properties and undergoes specific reactions based on the functional groups present; these reactions, including acid-base and oxidation reactions, can be used to identify the class of the organic compound. (ACSCH128)
- Data from analytical techniques, including mass spectrometry, (.........) and infrared spectroscopy, can be used to determine the structure of organic molecules, often using evidence from more than one technique. (ACSCH130)

Unit 4 - Chemical synthesis and design

- Chemical synthesis involves the selection of particular reagents to form a product with specific properties (for example, pharmaceuticals, fuels, cosmetics, cleaning products). (ACSCH131)
- Designing chemical synthesis processes includes identifying reagents and reaction conditions in order to maximise yield and purity of product. (ACSCH133)
- The yield of a chemical synthesis reaction can be calculated by comparing stoichiometric quantities with actual quantities. (ACSCH134)
- Organic molecules, including polymers, can be synthesised using addition, (substitution) and condensation reactions. (ACSCH136)
- Fuels (..........) can be synthesised from organic (......) sources using a range of chemical reactions including addition, oxidation and esterification. (ACSCH137)

Accreditation

The accreditation period for this course has been renewed from 1 January 2022 until 31 December 2024.

During the accreditation period required amendments can be considered via established processes.

Should outcomes of the Years 9-12 Review process find this course unsuitable for inclusion in the Tasmanian senior secondary curriculum, its accreditation may be cancelled. Any such cancellation would not occur during an academic year.

Version History

Version 1 – Accredited on 19 June 2014 for use in 2015 to 2018. This course replaces Chemistry (CHM315114) that expired on 31 December 2014.

Version 2 – As per TASC decision on 4 February 2015, this course has been assigned Level 4 (not 3) in complexity. The level and complexity section of this course document has been updated and the code changed to CHM415115.

Version 3 – Amendment approved 13 February 2015. Change to wording of analytical techniques dot point, p.12 to align with Australian curriculum document.

Version 3.1 - Modification of first sub-dot point under Chemical Stoichiometry to read, "review all reactions and calculations included in Physical Sciences Level 3: Criteria 7 & 8". (19 January 2018)

Accreditation renewed on 22 November 2018 for the period 1 January 2019 until 31 December 2021.

Version 3.2 - Renewal of Accreditation on 14 July 2021 for the period 31 December 2021 until 31 December 2024, without amendments.

Appendix 1

EXAMPLES IN CONTEXT

The following examples in context are sourced from the *Australian Senior Secondary Curriculum: Chemistry*. These examples have been selected to support the *Science Understanding* content of this course, and may be used to explore *Science as a Human Endeavour* concepts. The list provides a range of contexts in which the chemistry content related to Criteria 5, 6, 7 and 8 may also be applied to the impact of chemistry in society (Criterion 4).

The examples in context listed should **not** be taken as an exhaustive list, nor is it intended that all examples be explicitly delivered. The examples are support materials and **may** be used to: inspire assessment tasks, augment classroom teaching, stimulate discussion, or to simply act as exemplars for teachers.

Possible internal assessment tasks (based on the following or other relevant examples) may include written reports, essays, case studies, portfolios, scientific poster presentations, oral presentations and debates. Principles and concepts in the examples that are not part of *Science Understanding* content of this course will not be examined externally.

Scuba diving and the behaviour of gases

Safe scuba diving requires knowledge of the behaviour of gases with reference to volume, pressure and temperature. In particular, divers should understand how the volume of a gas varies with the surrounding pressure, in order to prevent damage to their respiratory, circulatory and nervous system. Diving equipment is designed to reduce the risk of dealing with gases at high pressure, including both the choice of materials used and the design of systems to improve efficiency and safety. Guidelines and regulations based on understanding of gas compression and expansion due to changes in water pressure enable divers to avoid conditions such as pulmonary barotrauma and decompression sickness.

The importance of enzymes

Enzymes are specific to particular reactions and act as important catalysts in many biological reactions, including those involved in digestion and respiration. Evidence for the existence and action of enzymes initially arose from Louis Pasteur's study of fermentation of sugar to form alcohol in the nineteenth century. Further work, involving a wide range of scientists, proposed that enzyme action was associated with protein molecules. Catalysts work in a variety of ways, and knowledge of the structure of enzyme molecules helps scientists to explain and predict how they are able to lower the activation energy for reactions. This work often relies on evidence from laboratory experiments as well as analytical methods used to determine the structure of molecules. For example, Australian John Cornforth was awarded the Nobel Prize for chemistry for his study of the molecular geometry of enzymes and how they are able to catalyse essential biochemical reactions.

Cost of corrosion

Corrosion of metals can have significant negative economic, environmental and safety consequences. For example, corrosion of steel pipes led to the 2008 gas plant explosion on Varunus Island, Western Australia, cutting the state's gas supply by 30%. Many heritage structures, particularly bridges, have significant corrosion issues that compromise user safety, such as corrosion of main cables on suspension bridges. Addressing these issues can be complex and costly, and decisions about maintenance or replacement often involve consideration of factors such as cost, aesthetic or cultural value, and safety. Most contemporary methods of corrosion prevention rely on knowledge of chemical and electrochemical redox processes, including the use of graphene within varnish coatings of iron or steel. The extension of a metal's useful life will achieve cost savings and improve environmental impacts for many Australian industries, where a significant amount of industry is located on the coast and/or relies on shipping for imports and exports.

Development of collision theory

Collision theory enables chemists to explain and predict the rates of a vast range of chemical reactions in many different contexts. German chemist Max Trautz published research about aspects of collision theory, in particular the significance of activation energy, in 1916. William Lewis, working independently in England at the same time, proposed complimentary work on collision theory in 1918. The First World War prevented not only the two chemists working together, but even being aware of each other's work. Further work on collision theory enabled a quantitative approach to be taken which allowed for the prediction and control of chemical reaction rates; these understandings are now used by chemical engineers to design efficient, safe and economically viable industrial processes.

Chemical balance in wine

The production of wine, along with that of many other food products, relies on the successful control of a range of reversible reactions in order to maintain the required chemical balance within the product. For wine, this balance includes the acidity, alcohol concentration, sugar levels and the colour of the wine. Techniques such as auto titration, gas chromatography and infrared spectroscopy are used to measure the chemical composition of wine. Data from these methods, including the analysis of multivariate data, has enabled scientists to identify how the concentrations of the various chemicals in the wine are related, both to each other and the observable properties of wine such as taste and aroma. Sulfur dioxide is used to maintain chemical balance in wine, as it binds with acetaldehyde. 'Sulfite calculators' are available so that wine makers can predict the amount of sulfur dioxide required. However decisions as to how the sulfur dioxide is added to the wine, including how much to use, will depend on preferences of the winemaker, especially for those producers who market wine as 'organic' or 'preservative free'.

Carbon dioxide in the atmosphere and hydrosphere

The levels of carbon dioxide in the atmosphere have a significant influence on global systems, including surface temperatures. The oceans contribute to the maintenance of steady concentrations of atmospheric carbon dioxide because the gas can dissolve in seawater through a range of reversible processes. The uptake of anthropogenic carbon dioxide by the oceans is driven by the difference in gas pressure in the atmosphere and in the oceans, and by the air/sea transfer velocity. Because carbon dioxide is increasing in the atmosphere, more of it moves into the ocean to balance the oceanic and atmospheric gas pressures, causing a change in the equilibrium point. Dissolved carbon dioxide increases ocean acidity, which is predicted to have a range of negative consequences for ecosystems, including direct impacts on oceanic calcifying organisms such as corals, crustaceans and molluscs because structures made of calcium carbonate are vulnerable to dissolution under at lower pH levels. The United Nations Kyoto Protocol and the establishment of the Intergovernmental Panel on Climate Change aim to secure global commitment to a significant reduction in greenhouse gas emissions over the next decades.

Breathalysers and measurement of blood alcohol levels

The level of alcohol in the body can be measured by testing breath or blood alcohol concentrations. These analysis techniques rely on redox reactions. Police first used breath testing for alcohol in the 1940s. Currently, a range of other detection methods are available to police, and commercially to drivers who are now able to test themselves before driving. Some meters use infrared spectroscopy to determine the amount of alcohol present, which can be converted to blood alcohol concentration (BAC). Electrochemical cells form the basis of 'alcosensors' that can also be used to measure BAC. These cells work by recording the electrical potential produced by the oxidation of the ethanol at platinum electrodes. Although science can provide information about the effect of alcohol on our bodies in relation to the ability to drive, decisions about 'safe' levels of BAC for driving (including those used to write legislation) take into account other factors, such as the experience of the driver, and can vary from country to country.

Fuel cells and their uses

Redox reactions that occur spontaneously can be used as a source of electrical energy. These include wet cells (such as car batteries), dry cells, and alkaline batteries. Fuel cells are electrochemical cells that use up a 'fuel', such as hydrogen. Fuel cells were first demonstrated in the 1840s, but were not commercially available until the late twentieth century. Currently, small fuel cells are designed for laptop computers and other portable electronic devices; larger fuel cells are used to provide backup power for hospitals; and wastewater treatment plants and landfills make use of fuel cells to capture and convert the methane gas they produce into methane. Fuel cells are a potential lower-emission alternative to the internal combustion engine and are already being used to power buses, boats, trains and cars. International organisations such as the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) have been created to foster international cooperation on research and development, common codes and standards, and information sharing on infrastructure development.

Electrochemistry for clean water

Electrochemistry has a wide range of uses, ranging from industrial scale metal extraction to personal cosmetic treatments. A new application has been in the treatment of mineral rich bore water. New Zealand scientists have trialled a system that uses electrochemistry to remove the iron and manganese ions present in bore water, which currently make the water undrinkable. An electric current converts chloride ions to chlorine, which then oxidises and precipitates out the metal contaminants, as well as disinfecting the water. The electric current passing through the water also dramatically increased the effectiveness of the chlorine in killing organisms in the water. The process requires minimal current and can be provided by a 12-volt car battery, which makes it a cheap and relatively 'low tech' solution suitable for use in rural areas of developing countries.

Functional groups and organic chemistry

Over 80 per cent of all known compounds are organic compounds. Initial work in the area of organic chemistry was based on observational chemistry, with nineteenth century attempts to organise the diversity of organic compounds based on grouping them according to their reactions. This theory was primarily based on empirical observations of reactivity, and did not consider the structure of the compounds. The theory of chemical structure was initially evident in work describing the concept of the interatomic bond, as formulated independently and simultaneously by Kekulé and Couper in 1858. Further advances in understanding of the chemical structure of carbon-based molecules led to a classification based on functional groups. The chemical behaviour of the molecule can now be predicted based on known chemistry of the functional groups it contains. Developments in computer modelling have enabled more accurate visualisation and prediction of three-dimensional organic structures, such as proteins, which is critical in drug design and biotechnology.

Green polymer chemistry

Polymers are common in daily life due to their extraordinary range of properties, and include natural polymeric materials such as wool, silk and natural rubber, and synthetic polymers such as synthetic rubber, neoprene, nylon, polystyrene and polypropylene. Contemporary applications of polymers include their use in organic light emitting diodes (OLEDs) to develop television, computer and mobile phone screens that are lighter, more flexible and more energy efficient than previous materials. Synthetic polymers often have large "ecological footprints" as they are synthesised from fossil fuels and do not biodegrade. There is significant research and development directed towards sustainable polymers, produced from renewable sources such as plants, waste products and waste gases. While there have been significant advances in this field, issues remain regarding the economic viability of this means of production, and use of food crops for the production of polymer materials rather than food.

Appendix 2

GLOSSARY

Analyse
Examine, scrutinise, explore, review, consider in detail for the purpose of finding meaning or relationships, and identifying patterns, similarities and differences.

Anomalous data
Data that does not fit a pattern; outlier.

Communicates
Conveys knowledge and/or understandings to others.

Complex
Consisting of multiple interconnected parts or factors.

Critically analyse
Examine the component parts of an issue or information, for example, identifying the premise of an argument and its plausibility, illogical reasoning or faulty conclusions.

Critically evaluate
Evaluation of an issue or information that includes considering important factors and available evidence in making critical judgement that can be justified.

Data
The plural of datum; the measurement of an attribute, for example, the volume of gas or the type of rubber. This does not necessarily mean a single measurement: it may be the result of averaging several repeated measurements. Data may be quantitative or qualitative and be from primary or secondary sources.

Demonstrate
Give a practical exhibition as an explanation.

Describe
Give an account of characteristics or features.

Evaluate
Provide a detailed examination and substantiated judgement concerning the merit, significance or value of something.

Evidence
In science, evidence is data that is considered reliable and valid and which can be used to support a particular idea, conclusion or decision. Evidence gives weight or value to data by considering its credibility, acceptance, bias, status, appropriateness and reasonableness.

Explain
Provide additional information that demonstrates understanding of reasoning and/or application.

Familiar
Previously encountered in prior learning activities.

Genre
The categories into which texts are grouped; genre distinguishes texts on the basis of their subject matter, form and structure (for example, scientific reports, field guides, explanations, procedures, biographies, media articles, persuasive texts, narratives).

Identify
Establish or indicate who or what someone or something is.

Investigation
A scientific process of answering a question, exploring an idea or solving a problem that requires activities such as planning a course of action, collecting data, interpreting data, reaching a conclusion and communicating these activities. Investigations can include observation, research, field work, laboratory experimentation and manipulation of simulations.

Law
A statement describing invariable relationships between phenomena in specified conditions, frequently expressed mathematically.

Mode
The various processes of communication – listening, speaking, reading/viewing and writing/creating.

Model
A representation that describes, simplifies, clarifies or provides an explanation of the workings, structure or relationships within an object, system or idea.

Primary data
Data collected directly by a person or group.

Primary source
Report of data created by the person or persons directly involved in observations of one or more events, experiments, investigations or projects.

Random error
Uncontrollable effects of the measurement equipment, procedure and environment on a measurement result; the magnitude of random error for a measurement result can be estimated by finding the spread of values around the average of independent, repeated measurements of the quantity.

Reasoned
Reasoned argument/conclusion: one that is sound, well-grounded, considered and thought out.

Reliable data
Data that has been judged to have a high level of reliability; reliability is the degree to which an assessment instrument or protocol consistently and repeatedly measures an attribute achieving similar results for the same population.

Reliability
The degree to which an assessment instrument or protocol consistently and repeatedly measures an attribute achieving similar results for the same population.

Representation
A verbal, visual, physical or mathematical demonstration of understanding of a science concept or concepts. A concept can be represented in a range of ways and using multiple modes.

Research
To locate, gather, record, attribute and analyse information in order to develop understanding.

Research ethics
Norms of conduct that determine ethical research behaviour; research ethics are governed by principles such as honesty, objectivity, integrity, openness and respect for intellectual property and include consideration of animal ethics.

Risk assessment
Evaluations performed to identify, assess and control hazards in a systematic way that is consistent, relevant and applicable to all school activities. Requirements for risk assessments related to particular activities will be determined by jurisdictions, schools or teachers as appropriate.

Secondary data
Data collected by a person or group other than the person or group using the data.

Secondary source
Information that has been compiled from records of primary sources by a person or persons not directly involved in the primary event.

Significant figures
The use of place value to represent a measurement result accurately and precisely.

Simulation
A representation of a process, event or system that imitates a real or idealised situation.

Solve
Work out a correct solution to a problem.

System
A group of interacting objects, materials or processes that form an integrated whole. Systems can be open or closed.

Systematic error
The contribution to the uncertainty in a measurement result that is identifiable and quantifiable, for example, imperfect calibration of measurement instruments.

Theory
A set of concepts, claims and/or laws that can be used to explain and predict a wide range of related observed or observable phenomena. Theories are typically founded on clearly identified assumptions, are testable, produce reproducible results and have explanatory power.

Uncertainty
Range of values for a measurement result, taking account of the likely values that could be attributed to the measurement result given the measurement equipment, procedure and environment.

Unfamiliar
Not previously encountered in prior learning activities.

Validity
The extent to which tests measure what was intended; the extent to which data, inferences and actions produced from tests and other processes are accurate.

Virtual
Having the attributes of something without sharing its (real or imagined) physical form.

Supporting documents including external assessment material

- CHM415115 Exam Paper 2016.pdf (2022-02-22 11:10am AEDT)
- CHM415115 Assessment Report 2016.pdf (2017-07-25 04:05pm AEST)
- Use Of Calculator Policy 2017.pdf (2017-07-25 04:07pm AEST)
- CHM415115 Exam Paper 2017.pdf (2017-11-23 04:56pm AEDT)
- CHM415114 Assessment Report 2017.pdf (2018-03-05 11:59am AEDT)
- CHM415115 TASC Exam Paper 2018.pdf (2018-11-22 12:27pm AEDT)
- CHM415115 - Assessment Panel Report and Solutions 2018.pdf (2019-03-07 04:33pm AEDT)
- CHM315115 Chemistry TASC Exam Paper 2019.pdf (2019-11-12 04:16pm AEDT)
- CHM415115 Assessment Report 2019.pdf (2020-02-03 09:20am AEDT)
- CHM415115 Chemistry TASC Exam Paper 2020.pdf (2020-11-19 09:12pm AEDT)
- CHM415115 Assessment Report 2020.pdf (2021-01-13 10:27am AEDT)
- CHM415115 External Assessment Specifications.pdf (2021-02-25 09:11am AEDT)
- CHM415115 Information Sheet.pdf (2021-03-22 01:08pm AEDT)
- CHM415115 Chemistry TASC Exam Paper 2021.pdf (2021-11-09 12:26pm AEDT)