Scottish Qualifications Authority

CHEMISTRY
Advanced Higher

Fourth edition – published June 2002

NOTE OF CHANGES TO ADVANCED HIGHER ARRANGEMENTS FOURTH EDITION PUBLISHED JUNE 2002

COURSE TITLE:	Chemistry (Advanced Higher)
COURSE NUMBER:	C012 13

National Course Specification

Course Details	Component units numbered. Aspects of Outcome 1 performance criteria numbered. Minor amendments to content statements (Units for K_w deleted; 'rate equation' statement amended; statement on 'crystal as a diffraction grating' amended). Details of the instruments for external assessment amended. Grade descriptions expanded. Details of the instruments for internal assessment added including clarification of assessment requirements for Outcome 3.

National Unit Specification

D072 13 Electronic Structure and the Periodic Table
D073 13 Principles of Chemical Reactions
D074 13 Organic Chemistry

General Information	Clarification of assessment requirements for Outcome 3
Statement of Standards	Aspects of Outcome 1 performance criteria numbered Clarification of assessment requirements for Outcome 3
Support notes	Advice on the assessment of Outcome 3 expanded and clarified

D075 13 Chemical Investigation

Support notes	Minor amendments Advice on assessment of Outcome 2 expanded

SCOTTISH QUALIFICATIONS AUTHORITY

National Course Specification

CHEMISTRY (ADVANCED HIGHER)

COURSE NUMBER C012 13

COURSE STRUCTURE

This course has four mandatory units:

D072 13	***Electronic Structure and the Periodic Table (AH)***	***0.5 credit (20 hours)***
D073 13	***Principles of Chemical Reactions (AH)***	***1 credit (40 hours)***
D074 13	***Organic Chemistry (AH)***	***1 credit (40 hours)***
D075 13	***Chemical Investigation (AH)***	***0.5 credit (20 hours)***

In common with all courses, this course includes a further 40 hours over and above the 120 hours for component units. This is for induction, extending the range of learning and teaching approaches, support, consolidation, integration of learning and preparation for external assessment. This time is an important element of the course and advice on its use is included in the course details.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates will normally be expected to have attained one of the following:

- Higher Chemistry course or its component units
- Equivalent.

Administrative Information

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National Course Specification: general information (cont)

COURSE Chemistry (Advanced Higher)

CORE SKILLS

Core skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001)

National Course Specification: course details

COURSE Chemistry (Advanced Higher)

RATIONALE

The study of chemistry at Advanced Higher level develops the candidate's knowledge and understanding of the physical and natural environments. The course builds on the Higher level, developing further the underlying theories of chemistry and the practical skills used in the chemical laboratory. The course also develops the skills of independent study and thought that are essential in a wide range of occupations.

The course is particularly suitable for candidates who wish to progress to degree courses either in chemistry or in subjects of which chemistry is a major component such as medicine, chemical engineering, and the environmental and health sciences.

The course also provides a sound basis for direct entry into chemistry-related employment.

The course is designed to allow candidates to develop:

- knowledge and understanding of chemical facts, theories and symbols
- the ability to solve chemical problems
- the ability to carry out chemical techniques and a chemical investigation
- an awareness of the relationship between experimental evidence and chemical theory.

In problem solving, the candidates will be expected to:

- select and present information
- carry out calculations
- plan, design and evaluate experimental procedures
- draw conclusions and give explanations
- make generalisations and predictions.

As a result of engaging in practical work candidates will be expected to:

- describe experimental procedures
- record relevant measurements and observations
- analyse experimental information
- draw valid conclusions
- evaluate experimental procedures with supporting argument.

In addition, the learning experiences make an important contribution to candidates' general education by:

- creating a positive image of chemistry
- providing examples of the relevance of chemistry to everyday living
- raising awareness of the links between chemistry and the world of work
- emphasising the importance of the chemical industry
- developing core skills
- developing the skills of independent study and research.

National Course Specification: course details (cont)

COURSE Chemistry (Advanced Higher)

COURSE CONTENT

A series of detailed content statements are given for each unit of the course.

The content statements in the tables on the following pages describe in detail the knowledge and understanding associated with the three content units of the course, and will be subject to sampling in the external assessment.

Achievement will require to be shown in a variety of ways, that is candidates will be expected to 'state', 'describe', 'explain', 'identify', etc, as appropriate.

The right-hand column of each table is reserved for suggested activities related to the content statements. The suggested activities do not form a complete or comprehensive list.

It should be noted that the content statements have been arranged in unit sequence. For learning and teaching purposes teachers/lecturers may wish to reorder the content, either within units if the units are being taught separately or within and between units if the units are being taught as an integrated course.

It should also be noted that, while the units are valuable in their own right, candidates will gain considerable additional benefit from completing this course, since there will be opportunities for the integration of knowledge and skills across the units.

All candidates will be expected to carry out the Prescribed Practical Activities listed below. These are also highlighted in italics under Suggested Activities.

ACTIVITY	**UNIT**
Preparation of Potassium Trioxalatoferrate(III)	1
Colorimetric Determination of Manganese in Steel	1
Complexometric Determination of Nickel using EDTA	2
Gravimetric Determination of Water in Hydrated Barium Chloride	2
Determination of a Partition Coefficient	2
Verification of a Thermodynamic Prediction	2
Kinetics of the Acid-Catalysed Propanone/Iodine Reaction	2
Preparation of Cyclohexene	3
Identification by Derivative Formation	3
Preparation of Benzoic Acid by Hydrolysis of Ethyl Benzoate	3
Preparation of Aspirin	3
Aspirin Determination	3

National Course Specification: course details (cont)

COURSE Chemistry (Advanced Higher)

Unit 1: Electronic Structure and the Periodic Table (AH)

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
(a) Electronic structure **(i) Electromagnetic spectrum and associated calculations** Electromagnetic radiation may be described in terms of waves.	
Electromagnetic radiation can be specified by its wavelength (λ) and by its frequency (ν).	View dispersion of white light by a prism.
The electromagnetic spectrum is the range of frequencies or wavelengths of electromagnetic radiation.	Consider frequencies and wavelengths of different regions of the electromagnetic spectrum.
The unit of measurement of wavelength is the metre or an appropriate sub-multiple. The unit of measurement of frequency is the reciprocal of time in seconds (s^{-1}) and is called the Hertz (Hz).	
The velocity of electromagnetic radiation is constant and has a value of approximately 3×10^8 ms^{-1}.	
Velocity, frequency and wavelength are related in the expression: $c = \lambda \nu$	
Under certain circumstances electromagnetic radiation may be regarded as a stream of particles, rather than as waves. These particles are known as photons.	
The energy (E) of radiation, and the energy associated with photons, is related to frequency by Planck's constant (h) in the expressions: $E = h\nu$ for one photon $E = Lh\nu$ for one mole of photons where L is Avogadro's Constant.	Calculate energies associated with different regions of the electromagnetic spectrum. Calculate frequencies of electromagnetic radiation required to break covalent bonds, eg of chlorine molecules in the reaction of chlorine with hydrogen and of molecular species in the atmosphere.

National Course Specification: course details (cont)

COURSE Chemistry (Advanced Higher)

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
(ii) Electronic configuration and the Periodic Table The emission spectrum of hydrogen provides evidence of energy levels.	Carry out flame tests viewed through direct vision spectrometer or diffraction grating. View discharge tubes.
Quantum theory states that matter can only emit or absorb energy in small fixed amounts (called quanta).	Find out about street lamps.
The energy of a bound electron in an atom is quantised.	
An atom can be considered as emitting a photon of light energy when an electron moves from a higher energy level to a lower energy level.	
Each line of the emission spectrum represents radiation of a specific wavelength or frequency from which the difference in energy between the levels can be calculated.	
Emission spectra of elements with more than one electron provide evidence of sublevels within each principal energy level above the first.	
The principal energy levels correspond to the principal shells. The second and subsequent principal shells contain subshells which correspond to the sublevels.	
Subshells can be labelled s, p, d and f.	
The types of subshells within each principal shell are as follows: First shell — s subshell Second shell — s and p subshells Third shell — s, p and d subshells Fourth and subsequent shells — s, p, d and f subshells	

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Heisenberg's uncertainty principle states that it is impossible to define with absolute precision, simultaneously, both the position and the momentum of an electron. Electrons, like photons, display the properties of particles and waves. Treating bound electrons in atoms as waves leads to regions of high probability of finding the electrons. These regions are called atomic orbitals. There are four types of orbitals, namely s, p, d and f, each with a characteristic shape or set of shapes. Diagrams of the shapes of s and p orbitals can be drawn and recognised. Diagrams of d orbitals can be recognised An orbital holds a maximum of two electrons, as required by the Pauli exclusion principle. The number of orbitals in each subshell is as follows : s subshell one s orbital p subshell three p orbitals d subshell five d orbitals f subshell seven f orbitals In an isolated atom the orbitals within each subshell are degenerate. The aufbau principle states that orbitals are filled in order of increasing energy. The relative energies corresponding to each orbital can be represented diagrammatically for the first four shells of a multi-electron atom. Hund's Rule states that when degenerate orbitals are available, electrons fill each singly, keeping their spins parallel before spin pairing starts.	

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Electronic configurations using spectroscopic notation and orbital box notation can be written for elements of atomic numbers 1 to 36. The Periodic Table can be subdivided into four blocks (s, p, d and f) corresponding to the outer electronic configurations of the elements within these blocks. The variation in first ionisation energy with increasing atomic number for the first 36 elements can be explained in terms of the relative stability of different electron configurations, and so provides evidence for these electronic configurations. The relative values of first, second and subsequent ionisation energies can be explained in terms of the stabilities of the electronic configurations from which the electrons are being removed.	Derive electronic structure of several elements from table of relative energy levels. Plot graph of ionisation energy against atomic number. (ITO)
(iii) Spectroscopy Atomic emission spectroscopy and atomic absorption spectroscopy involve transitions between electronic energy levels in atoms. Generally, the energy differences correspond to the visible region of the electromagnetic spectrum, ie, to the approximate wavelength range of 400-700 nm. Some applications use the ultra-violet region (wavelength range approximately 200-400 nm). In emission spectroscopy the sample is energised by heat or electricity causing electrons to be promoted to higher energy levels. The wavelength of the radiation emitted as electrons fall back to lower energy levels is measured. In absorption spectroscopy electromagnetic radiation is directed at the sample. Radiation is absorbed as electrons are promoted to higher energy levels. The wavelength of the absorbed radiation is measured. Each element provides a characteristic spectrum which can be used to identify an element. The amount of species can be determined quantitatively if the intensity of emitted or transmitted radiation is measured.	Observe line spectra of elements. View Modern Chemical Techniques video (Royal Society of Chemistry) Find out about uses of atomic emission and absorption spectrometry. Examples include: determination of lead and aluminium in drinking water determination of metals in effluent water.

National Course Specification: course details (cont)

COURSE Chemistry (Advanced Higher)

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
(b) Chemical Bonding **(i) Covalent bonding** Non-polar covalent bonding and ionic bonding can be considered as being at opposite ends of a bonding continuum with polar covalent bonding lying between these two extremes. Different electron models can be used to explain the experimental evidence associated with covalent bonding.	
Lewis electron dot diagrams represent bonding and non-bonding electron pairs in molecules and in polyatomic ions. A dative covalent bond is one in which one atom of the bond provides both electrons of the bonding pair. Species such as ozone, sulphur dioxide and the carbonate ion can be represented by equivalent electron dot diagrams known as resonance structures.	Draw resonance structures of various species.
(ii) Shapes of molecules and polyatomic ions The shapes of molecules or polyatomic ions can be predicted from the number of bonding electron pairs and the number of non-bonding electron pairs. The arrangement of electron pairs is linear, trigonal, tetrahedral, trigonal bipyramidal and octahedral when the total number of electron pairs is 2, 3, 4, 5 and 6, respectively. Electron pair repulsions decrease in strength in the order: non-bonding pair/non-bonding pair > non-bonding pair/bonding pair > bonding pair/bonding pair. These different strengths of electron pair repulsion account for slight deviations from expected bond angles in molecules such as NH_3 and H_2O.	Use models to study shapes of molecules.

COURSE Chemistry (Advanced Higher)

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
(iii) Ionic lattices, superconductors and semiconductors *Ionic lattice structures* The geometry of the crystalline structure adopted by an ionic compound depends on the relative sizes of the ions. This affects the number of ions which can pack round an ion of opposite charge. Examples of crystal lattice structures are: sodium chloride caesium chloride	Study/make models of sodium chloride lattice and caesium chloride lattice. Observe models of other crystal structures, eg, zinc blende, fluorite and rutile.
Superconductors Superconductors are a special class of materials that have zero electrical resistance at temperatures near absolute zero. Achieving temperatures near absolute zero is difficult and costly so application of superconduction at these temperatures is impractical. Recently superconductors have been discovered which have zero resistance up to temperatures above the boiling point of liquid nitrogen - temperatures which are less costly to attain. Superconductors may have future applications in power transmission and electrically powered forms of transport.	Research information on structures of superconductors and applications.

National Course Specification: course details (cont)

COURSE Chemistry (Advanced Higher)

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Semiconductors A covalent element such as silicon or germanium which has a higher conductivity than that of a typical non-metal but a much lower conductivity than that of a metal is described as a semiconductor.	
Semiconductors are also referred to as metalloids and occur at the division between metals and non-metals in the Periodic Table.	
The electrical conductivity of semiconductors increases with increasing temperature. The electrical conductivity of semiconductors increases on exposure to light. This is known as the photovoltaic effect.	Investigate the effect of temperature on the conductivity of silicon.
Elements such as silicon and germanium have similar structures to diamond but the covalent bonds are weaker. Thermal agitation of the lattice can result in some of the bonding electrons breaking free, leaving positive sites called 'holes'.	
When a voltage is applied to these elements, electrons and holes can migrate through the lattice.	
Doping pure crystals of silicon or germanium with certain other elements produces n-type and p-type semiconductors.	
The type of semiconduction depends on the specific dopant used.	Find out about uses of semiconductors.
In n-type and p-type semiconductors the main current carriers are surplus electrons and positive holes respectively.	Read about the manufacture of silicon of high purity by zone refining.

COURSE Chemistry (Advanced Higher)

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Crystals of silicon or germanium can be prepared with bands of n-type or p-type semiconductors. The p-n junction which occurs between a layer of n-type and a layer of p-type semiconductor has specific electrical properties which form the basis of the electronics industry.	
Solar cells use the photovoltaic effect to convert sunlight into electricity.	
(c) Some chemistry of the Periodic Table **(i) The second and third short periods: oxides, chlorides and hydrides** Melting points, boiling points and electrical conductivities of the oxides, chlorides and hydrides of the elements of the second and third periods can be explained in terms of their structure and type of bonding.	
Metal oxides tend to be basic and non-metal oxides tend to be acidic but amphoteric oxides exhibit both acidic and basic properties.	Observe the reactions of a range of oxides with water. Prepare a sample of aluminium hydroxide and observe its reaction with dilute acid and alkali.
Most ionic chlorides dissolve in water without reaction but some covalent chlorides are hydrolysed, producing fumes of hydrogen chloride.	Demonstrate the preparation of a metal chloride and a non-metal chloride. Observe the reactions of a range of chlorides with water.
Ionic hydrides possess the hydride ion which acts as a reducing agent. On reaction with water ionic hydrides produce hydrogen gas and the hydroxide ion.	Demonstrate the reduction of a metal oxide with a suitable ionic hydride. Observe the reaction of calcium hydride with water.
Electrolysis of molten ionic hydrides produces hydrogen gas at the positive electrode.	Discuss/research the use of ionic hydrides as a possible means of storing hydrogen for hydrogen-powered vehicles.

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
(ii) Electronic configuration and oxidation states of transition metals *Electronic configuration* The d block transition metals are metals with an incomplete d subshell in at least one of their ions.	
The filling of the d orbitals follows the aufbau principle, with the exception of chromium and copper atoms. These exceptions are due to a special stability associated with all the d orbitals being half filled or completely filled.	
When transition metals form ions it is the s electrons which are lost first rather than the d electrons.	
Oxidation states An element is said to be in a particular oxidation state when it has a specific oxidation number.	
The oxidation number is determined by following certain rules.	
Transition metals exhibit variable oxidation states of differing stability.	
Compounds of the same transition metal but in different oxidation states may have different colours.	Investigate the reduction of ammonium vanadate(V).
Oxidation can be considered as an increase in oxidation number and reduction can be considered as a decrease in oxidation number.	
Compounds containing metals in high oxidation states tend to be oxidising agents whereas compounds with metals in low oxidation states are often reducing agents.	Investigate the oxidation reactions of manganate(VII) ions and dichromate(VI) ions.

National Course Specification: course details (cont)

COURSE Chemistry (Advanced Higher)

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
(iii) Transition metal complexes A complex consists of a central metal ion surrounded by ligands.	
Ligands are electron donors and may be negative ions or molecules with non-bonding pairs of electrons. Ligands can be classified as monodentate, bidentate, etc.	*Preparation of potassium trioxalatoferrate(III).*
The number of bonds from the ligand to the central metal ion is known as the co-ordination number of the central ion.	Find out about structure and operation of haemoglobin.
Complexes are written and named according to IUPAC rules.	
In a complex of a transition metal the d orbitals are no longer degenerate.	
The energy difference between subsets of d orbitals depends on the position of the ligand in the spectrochemical series.	
Colours of many transition metal complexes can be explained in terms of d-d transitions.	
UV and visible spectroscopy The effects of d-d transitions can be studied using ultra-violet and visible absorption spectroscopy.	
Ultra-violet and visible absorption spectroscopy involve transitions between electronic energy levels in atoms and molecules where the energy difference corresponds to the ultra-violet and visible regions of the electromagnetic spectrum.	Observe RSC video. Observe visible and uv spectra for some transition metal complexes.
The wavelength ranges are approximately 200-400 nm for ultra-violet and 400-700 nm for visible.	Perform uv and/or visible spectroscopy on some transition metal complexes.
An ultra-violet/visible spectrometer measures the intensity of radiation transmitted through the sample and compares this with the intensity of incident radiation.	Research applications of UV and visible spectroscopy. *Colorimetric determination of manganese in steel.*

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Catalysis Transition metals or their compounds act as catalysts in many chemical reactions.	
It is believed that the presence of unpaired d electrons or unfilled d orbitals allows intermediate complexes to form, providing reaction pathways of lower energy compared to the uncatalysed reaction.	Find out about the use transition metals and their compounds as catalysts.
The variability of oxidation states of transition metals is also an important factor.	React a solution of Rochelle salt with hydrogen peroxide using cobalt(II) chloride as a catalyst.

COURSE Chemistry (Advanced Higher)

Unit 2: Principles of Chemical Reactions (AH)

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
(a) Stoichiometry A quantitative reaction is one in which the substances react completely according to the mole ratios given by the balanced (stoichiometric) equation. Volumetric analysis involves using a solution of accurately known concentration in a quantitative reaction to determine the concentration of another substance. A solution of accurately known concentration is known as a standard solution. A standard solution can be prepared directly from a primary standard. A primary standard must have, at least, the following characteristics: • high state of purity • stability • solubility • reasonably high formula mass. The volume of reactant solution required to just complete the reaction is determined by titration.	
The equivalence point is the point at which the reaction is just complete. The 'end point' is the point at which a change is observed and is associated with the equivalence point. An indicator is a substance which changes colour at the end-point.	Investigate pH range over which colour change occurs for various indicators.
Acid/base titrations are based on neutralisation reactions.	Determine the acid content of vinegar.
Complexometric titrations are based on complex formation reactions. EDTA is an important complexometric reagent and can be used to determine the concentration of metal ions such as nickel(II).	*Complexometric determination of nickel using EDTA.*

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Redox titrations are based on redox reactions. Substances such as potassium manganate (VII) which can act as their own indicators are very useful reactants in redox titrations.	Estimate the percentage of anhydrous sodium sulphite in crystals.
In gravimetric analysis the mass of an element or compound present in a substance is determined by chemically changing that substance into some other substance of known chemical composition, which can be readily isolated, purified and weighed.	Determine H_2O in $BaCl_2.xH_2O$. *Gravimetric determination of water in hydrated barium chloride.*
(b) Chemical equilibrium **(i) Reactions at equilibrium** A chemical reaction is in equilibrium when the composition of the reactants and products remains constant indefinitely. The equilibrium constant (K) characterises the equilibrium composition of the reaction mixture. The equilibrium constant can be measured in terms of concentrations or, for gaseous reactions, in terms of pressure. For the general reaction: $a\text{A} + b\text{B} \rightleftharpoons c\text{C} + d\text{D}$ $K = \frac{[\text{C}]^c[\text{D}]^d}{[\text{A}]^a[\text{B}]^b}$ where [A], [B], [C] and [D] are the equilibrium concentrations of A, B, C and D, respectively, and *a, b*, *c* and *d* are the stoichiometric coefficients in a balanced reaction equation. In a homogeneous equilibrium all the species are in the same phase. In a heterogeneous equilibrium the species are in more than one phase.	

National Course Specification: course details (cont)

COURSE Chemistry (Advanced Higher)

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
The concentrations of pure solids or pure liquids are constant and are given the value 1 in the equilibrium equation. Equilibrium constants are independent of the particular concentrations or pressures of species in a given reaction. Equilibrium constants depend on the reaction temperature. Le Chatelier's principle states that when a reaction at equilibrium is subject to change the composition alters in such a way as to minimise the effects of that change. For endothermic reactions a rise in temperature causes an increase in K, ie, the yield of the product is increased. For exothermic reactions a rise in temperature causes a decrease in K, ie, the yield of the product is decreased. The effects of changes in concentration or pressure on the position of equilibrium can be explained quantitatively in terms of a fixed equilibrium constant. The presence of a catalyst does not affect the equilibrium constant.	
(ii) Equilibria between different phases *Partition coefficient* When a solute is shaken in two immiscible liquids it partitions itself between the two liquids in a definite ratio called the partition coefficient. The value of the partition coefficient depends on the immiscible liquids involved, the solute and the temperature.	*Determination of a partition coefficient.*

National Course Specification: course details (cont)

COURSE Chemistry (Advanced Higher)

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Solvent extraction Solvent extraction is an application of the partition of a solute between two liquids.	Find out about the use in the nuclear industry of solvent extraction for the separation of plutonium and uranium compounds in spent fuel - the 'Purex' process.
Applications of solvent extraction include the purification of water-soluble organic acids using a suitable organic solvent.	Find out about the use of supercritical CO_2 in the preparation of instant coffee compared with the previous use of dichloromethane. Discuss selection of suitable solvents for solvent extraction.
Chromatography Chromatographic separations depend on the partition equilibrium between two phases, one stationary and the other mobile. There are several types of chromatography. Examples are: paper chromatography gas liquid chromatography.	
In paper chromatography, the stationary phase is the water held on the paper and the mobile phase is another solvent.	Separate plant dyes and/or other mixtures by paper chromatography and TLC.
In gas-liquid chromatography the stationary phase is a liquid held on a solid support and the mobile phase is a gas.	Find out about use of GLC for determination of blood alcohol levels.

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
(iii) Equilibria involving ions *Acid/Base equilibria* The Bronsted-Lowry definitions of acid and base state that an acid is a proton donor and a base is a proton acceptor. For every acid there is a conjugate base, formed by loss of a proton. For every base there is a conjugate acid, formed by gain of a proton. The ionisation of water can be represented by: $H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$ Water is amphoteric. The dissociation constant for the ionisation of water is known as the ionic product and is represented by: $K_w = [H_3O^+][OH^-]$	
The value of the ionic product varies with temperature. At 25°C the value of K_w is approximately 1 x 10^{-14}. A shorthand representation of H_3O^+ is H^+. Stoichiometric equations and equilibrium expressions can be written using H^+ instead of H_3O^+ where the meaning is clear. The relationship between pH and the hydrogen ion concentration is given by $pH = -\log_{10}[H^+]$	From a data book find out about the variation of K_w with temperature.

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
The dissociation in aqueous solution of an acid of general formula HA can be represented as: $HA(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq)$ The acid dissociation constant of acid HA is given by: $K_a = \frac{[H_3O^+][A^-]}{[HA]}$ The conjugate base of an acid of general formula HA is A^-. The dissociation constant of an acid can be represented by pK_a where:	
$pK_a = -\log K_a$	Determine K_a and pK_a for a weak acid by measurement of pH.
The relationship of the pH of a weak acid to its dissociation constant is given by $pH = \frac{1}{2} pK_a - \frac{1}{2} \log c$ The dissociation in aqueous solution of base of general formula B can be represented as: $B(aq) + H_2O(l) \rightleftharpoons BH^+(aq) + OH^-(aq)$ The conjugate acid of a base of general formula B is BH^+. The dissociation of the conjugate acid of the base can be represented as: $BH^+(aq) + H_2O(l) \rightleftharpoons B(aq) + H_3O^+(aq)$	

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
The dissociation constant for the conjugate acid is: $K_a = \frac{[B]\,[H_3O^+]}{[BH^+]}$ *Indicators* Indicators are weak acids for which the dissociation can be represented as: $HIn(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + In^-(aq)$ The acid indicator dissociation constant is represented as K_{In} and is given by the following expression: $K_{In} = \frac{[H_3O^+]\,[In^-]}{[HIn]}$ In aqueous solution the colour of the acid indicator is distinctly different from that of its conjugate base. The colour of the indicator is determined by the ratio of [HIn] to $[In^-]$. The theoretical point at which colour change occurs is when $[H^+] = K_{In}$	
The colour change is assumed to be distinguishable when [HIn] and $[In^-]$ differ by a factor of 10.	Extract a dye from a plant and determine pH range over which colour changes.
The pH range over which a colour change occurs can be estimated by the expression: $pH = pK_{In} \pm 1$	Select and use appropriate indicators for titration of: weak acid and strong base strong acid and weak base.

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Buffer solutions A buffer solution is one in which the pH remains approximately constant when small amounts of acid or base are added. An acid buffer consists of a solution of a weak acid and one of its salts. In an acid buffer solution the weak acid can supply hydrogen ions when these are removed by the addition of a small amount of base. The salt of the weak acid provides the conjugate base, which can absorb excess hydrogen ions produced by the addition of a small amount of acid. A basic buffer consists of a solution of a weak base and one of its salts. In a basic buffer solution the weak base removes excess hydrogen ions and the conjugate acid provided by the salt supplies hydrogen ions when these are removed. The pH of an acid buffer solution can be calculated from its composition and from the acid dissociation constant. $[H_3O^+(aq)] = K_a \times \frac{[\text{acid}]}{[\text{salt}]}$ or $pH = pK_a - \log \frac{[\text{acid}]}{[\text{salt}]}$	Investigate effect on pH of addition of acid and alkali.
The required composition of an acid buffer solution can be calculated from the desired pH and from the acid dissociation constant.	Prepare buffer solution, measure pH and compare with calculated value.

National Course Specification: course details (cont)

COURSE Chemistry (Advanced Higher)

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
(c) Thermochemistry **(i) Hess's Law** Thermochemistry concerns the study of changes in energy which occur during chemical reactions. The First Law of Thermodynamics states that energy is conserved. Hess's law states that the overall reaction enthalpy is the sum of the reaction enthalpies of each step of the reaction. This is an application of the First Law of Thermodynamics. A thermochemical cycle can be used to calculate an unknown enthalpy value. The term 'standard enthalpy change' (ΔH^o) refers to an enthalpy change for a reaction in which the reactants and products are considered to be in their standard states at a specified temperature. The standard state of a substance is the most stable state of the substance under standard conditions. Standard conditions refer to a pressure of one atmosphere and a specified temperature, usually 298K (25°C). The standard molar enthalpy of combustion refers to the enthalpy change which occurs when one mole of a substance is burned completely.	
Calorimetry is the term used to describe the quantitative determination of the change in heat energy which occurs during a chemical reaction.	Research data on calorific values of foods and fuels. Find out how the data is obtained.
A calorimeter is used to measure the quantity of heat energy given out or taken in during a chemical reaction.	Find out about a bomb calorimeter. Calculate enthalpy of combustion from bomb calorimeter data.

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
The standard molar enthalpy of formation refers to the enthalpy change which occurs when one mole of a substance is prepared from its elements in their standard states. The standard enthalpy of formation of a substance can be calculated from standard enthalpy changes which are experimentally determined. The standard enthalpy of a reaction can be calculated from tabulated standard molar enthalpies of formation using the relation: $\Delta H^o = \Sigma\Delta H^o_f(products) - \Sigma\Delta H^o_f(reactants)$ **(ii) Bond enthalpies** For a diatomic molecule, XY, the molar bond enthalpy is the energy required to break one mole of XY bonds, that is, for the process: X-Y(g) $\rightarrow$ X(g) + Y(g) Mean molar bond enthalpies are average values which are quoted for bonds which occur in different molecular environments. Bond enthalpies may be calculated from data on enthalpy changes. The enthalpy of a reaction can be estimated from a thermochemical cycle involving bond formation and bond dissociation. Enthalpies of reaction estimated from bond enthalpies may differ from experimentally determined values.	Consider data on successive bond dissociation enthalpies for molecules of type XY_n.

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
(iii) Hess's Law applied to ionic substances *Born-Haber cycle* The Born-Haber cycle is a thermochemical cycle applied to the formation of an ionic crystal.	
The Born-Haber cycle can be used to calculate the enthalpy of lattice formation, which cannot be determined directly by experiment.	Compare values of lattice enthalpies obtained from the Born-Haber cycle with those obtained from theoretical calculations.
The standard molar enthalpy change of lattice formation is the enthalpy change which occurs when one mole of an ionic crystal is formed from the ions in their gaseous states under standard conditions.	
The cycle is a closed path which includes as steps the different enthalpy changes involved in the formation of an ionic crystal.	
The different enthalpy changes include enthalpy of atomisation, ionisation energy, bond enthalpy, electron affinity, lattice enthalpy and enthalpy of formation.	
The standard molar enthalpy of atomisation of an element is the energy required to produce one mole of isolated gaseous atoms from the element in its standard state. eg. $\frac{1}{2} I_2(s) \rightarrow I(g)$	
The electron affinity is usually defined as the enthalpy change for the process of adding one mole of electrons to one mole of isolated atoms in the gaseous state, ie, for the change represented by: $E(g) + e^- \rightarrow E^-(g)$	

COURSE Chemistry (Advanced Higher)

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Enthalpy of solution A thermochemical cycle can represent the relation between enthalpy of solution, enthalpy of lattice formation and enthalpy of hydration for the solution of an ionic compound. The hydration enthalpy is the energy released when one mole of individual gaseous ions becomes hydrated, ie, the changes represented by: $E^{n+}(g) \rightarrow E^{n+}(aq)$ and $E^{n-}(g) \rightarrow E^{n-}(aq)$ ***(d) Reaction feasibility*** **(i) Entropy** The entropy (*S*) of a system is the degree of disorder of the system. The greater the disorder, the greater the entropy. Entropy increases as temperature increases. Changes of state involve changes in entropy. Melting and evaporation are accompanied by increases in entropy. One version of the Third Law of Thermodynamics states that the entropy of a perfect crystal at 0K is zero. The standard entropy of a substance is the entropy value for the standard state of the substance. The change in standard entropy for a reaction system can be calculated from the standard entropy values for the reactants and products.	Determine enthalpies of solution by experiment and compare values with those predicted by thermochemical cycle.

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
(ii) Free energy One version of the Second Law of Thermodynamics states that the total entropy of a reaction system and its surroundings always increases for a spontaneous process.	
Heat energy released by the reaction system into the surroundings increases the entropy of the surroundings, whereas heat absorbed by the reaction system from the surroundings decreases the entropy of the surroundings.	Investigate simple exothermic and endothermic reactions. Discuss in terms of entropy changes.
The change in entropy of the surroundings that occurs as a result of a chemical reaction can be calculated from the temperature and from the enthalpy change for the reaction system.	
The total entropy change is proportional to the change in free energy (ΔG) of the reaction system. The direction of spontaneous change is in the direction of decreasing free energy.	
The change in standard free energy for a reaction is related to the standard enthalpy and entropy changes by: $\Delta G^o = \Delta H^o - T\,\Delta S^o$	
The standard free energy change of a reaction can be calculated from the standard enthalpy and standard entropy changes for the reaction.	
The standard free energy change of a reaction can be calculated from the standard free energies of formation of the reactants and products.	
A reaction is feasible under standard conditions if the change in standard free energy between reactants and products is negative. This means that the equilibrium composition favours the products over the reactants.	*Verification of a thermodynamic prediction.*

COURSE Chemistry (Advanced Higher)

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Under non-standard conditions any reaction is feasible if ΔG is negative.	
At equilibrium $\Delta G = 0$.	Consider graphs of free energy of reactants and products against changing composition of reaction mixture.
A reaction will proceed spontaneously in the forward direction until the composition is reached where $\Delta G = 0$.	
Applications of the concept of free energy The feasibility of a chemical reaction under standard conditions can be predicted from the calculated value of the change in standard free energy (ΔG^o).	
The temperature at which the reaction becomes feasible can be calculated for a reaction for which both ΔH^o and ΔS^o have positive values.	
Ellingham diagrams are plots of variation of free energy change with temperature and can be used to predict the conditions under which a reaction can occur.	
Ellingham diagrams can be used to predict the conditions required to extract a metal from its ores.	
(e) Electrochemistry A potential difference is set up when a metal is placed in contact with its ions in solution.	
An electrochemical cell is composed of two half cells between which electrical contact is made by an electrolyte, often in the form of a salt bridge.	
Cell and cell emf conventions should be employed according to IUPAC recommendations.	

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
For example, a cell reaction between zinc and copper can be represented as: $Zn \mid Zn^{2+}(aq) \mid\mid Cu^{2+}(aq) \mid Cu$ The equation for this cell is written as: $Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$. A positive emf is obtained if the reaction takes place in the direction as written. The emf of a cell (*E*) is the electric potential difference between the electrodes of the cell, ie, *E*(right) - *E*(left) when no current is drawn. Cell emf depends on the concentration, the temperature and the type of cell. Cell emf values are usually considered at standard conditions. Standard conditions for the measurement of electrode potentials refer to a situation in which all pressures are one atmosphere, concentrations of solutions are one mole per litre and in which temperature is specified normally at 298K (25°C). The absolute value of the electrode potential of a half cell cannot be determined experimentally. The standard electrode potential of a half cell is the potential measured against the standard hydrogen electrode under standard conditions. The standard hydrogen electrode potential is given an arbitrary value of 0·00V. The emf of a cell under standard conditions (E^o) can be calculated from the tabulated values of standard reduction potentials.	

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
The relative strengths of reducing agents and oxidising agents under standard conditions can be estimated from standard reduction potentials.	
For a standard cell operated under conditions of thermodynamic reversibility the standard free energy change for the cell reaction is related to cell emf by the expression: $\Delta G^o = -nFE^o$	Determine ΔS^o for the reaction of zinc with copper sulphate solution from the measurement of the emf of a standard cell and the measurement of the enthalpy of reaction.
A fuel cell operates like an electrochemical cell, the only difference being that the fuel for the reaction is provided from external reserves of gas, eg, the hydrogen/oxygen fuel cell.	Find out about the possible uses of hydrogen/oxygen fuel cells, eg for the development of pollution free transport.
(f) Kinetics The rate of a chemical reaction normally depends on the concentrations of the reactants.	
For a first order reaction the rate of reaction is proportional to the concentration of one reactant and the rate can be expressed as: rate = k [A]	
where k is the rate constant and [A] is the concentration of reactant A in mol l^{-1}.	
The order of a reaction with respect to any one reactant is the power to which the concentration of that reactant is raised in the rate equation.	Investigate rate of propanone/iodine reaction.
The overall order of a reaction is the sum of the powers to which the concentrations of the reactants are raised in the rate equation.	

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
In general for a reaction of type: aA + bB $\rightarrow$ products where the rate equation is of the form: rate = $k\,[A]^n\,[B]^m$ the order of reaction is *n* with respect to A and *m* with respect to B and the overall order is *n* + *m*.	
The rate constant can be determined from initial rate data for a series of reactions in which the initial concentrations of reactants are varied.	Investigate oxidation of iodide by persulphate and determine the rate constant using initial rate data.
Reaction mechanisms usually occur by a series of steps.	
The rate of reaction is dependent on the slowest step which is called the ‘rate determining step’.	
Experimentally determined rate equations can provide evidence for a proposed reaction mechanism but cannot provide proof, as other possible reaction mechanisms may also give the same rate equation.	*Kinetics of the acid-catalysed propanone/iodine reaction.*

National Course Specification: course details (cont)

COURSE Chemistry (Advanced Higher)

Unit 3: Organic Chemistry (AH)

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
(a) Permeating aspects of organic chemistry **(i) Reaction types** Equations can be written for the following reaction types and, given equations, these reaction types can be identified. substitution addition elimination condensation hydrolysis oxidation reduction **(ii) Reaction mechanisms** The following reaction mechanisms can be described in terms of electron shifts: i. radical substitution of alkanes ii. electrophilic addition to alkenes carbocation mechanism cyclic ion intermediate mechanism iii. nucleophilic substitution S_N1 and S_N2	

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
(iii) Physical Properties The following physical properties are explained in terms of the intermolecular forces involved: melting and boiling points miscibility with water. ***(b) Systematic organic chemistry*** **(i) Hydrocarbons and halogenoalkanes** Bonding in alkanes can be described in terms of sp^3 hybridisation and sigma bonds. Hybridisation is the process of mixing atomic orbitals in an atom to generate a set of new atomic orbitals called hybrid orbitals. A sigma (σ) bond is a covalent bond formed by end-on overlap of two atomic orbitals lying along the axis of the bond.	
Alkanes undergo substitution reactions with chlorine and bromine by a chain reaction mechanism. The chain reaction includes the following steps: i. initiation by homolytic fission to produce radicals ii. propagation iii. termination. Bonding in ethene can be described in terms of sp^2 hybridisation, sigma and pi bonds. A pi(π) bond is a covalent bond formed by the sideways overlap of two parallel atomic orbitals lying perpendicular to the axis of the bond.	React bromine solution with heptane in light.

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Alkenes can be prepared in the laboratory by:	
1. dehydration of alcohols using aluminium oxide, concentrated sulphuric acid or orthophosphoric acid 2. base-induced elimination of hydrogen halides from monohalogenoalkanes.	Dehydrate ethanol and test for ethene. *Preparation of cyclohexene.*
Alkenes undergo:	
1. catalytic addition with hydrogen to form alkanes 2. addition with halogens to form dihalogenoalkanes 3. addition with hydrogen halides according to Markovnikov's rule to form monohalogenoalkanes 4. acid-catalysed addition with water according to Markovnikov's rule to form alcohols.	React bromine solution with hexene or cyclohexene.
The mechanisms of the above reactions involve: 1. for halogenation — cyclic ion intermediate 2. for hydrohalogenation — carbocation intermediate 3. for acid catalysed hydration — carbocation intermediate	
Halogenoalkanes are named according to IUPAC rules.	
Monohalogenoalkanes can be classified as primary, secondary or tertiary.	
Monohalogenoalkanes undergo nucleophilic substitution reactions.	React monohalogenoalkanes with alkali and test for halide ion using aqueous ethanolic silver nitrate solution.
Monohalogenoalkanes undergo elimination reactions to form alkenes.	React monohalogenoalkanes with ethanolic potassium hydroxide and test for alkene produced.

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Monohalogenoalkanes react with: 1. alkalis to form alcohols 2. alcoholic alkoxides to form ethers 3. ethanolic cyanide to form nitriles which can be hydrolysed to carboxylic acids (chain length increased by one carbon atom) 4. ammonia to form amines via alkyl ammonium salts.	Investigate uses of halogenoalkanes.
(ii) Alcohols and ethers Alcohols exhibit hydrogen bonding and as a result have higher boiling points than other organic compounds of comparable relative formula mass and shape. The lower alcohols are miscible with water but as their chain length increases their solubility in water decreases. Alcohols can be prepared from: 1. alkenes by hydration 2. halogenoalkanes by substitution. In industry, alcohols (except methanol) can be manufactured by the acid-catalysed hydration of alkenes.	
Alcohols react with some reactive metals to form alkoxides.	Add sodium to ethanol.
Alcohols can be dehydrated to alkenes.	
Alcohols undergo condensation reactions slowly with carboxylic acids and more vigorously with acid chlorides to form esters.	Investigate uses of alcohols.

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Ethers have the general formula R'-O-R'' where R' and R'' are alkyl groups.	
Ethers are named according to IUPAC rules.	
Due to the lack of hydrogen bonding, ethers have lower boiling points than the corresponding isomeric alcohols.	
Ether molecules can hydrogen-bond with water molecules thus explaining the solubility in water of some ethers of low relative formula mass.	Consider solubility data for some ethers including tetrahydrofuran which is totally soluble in water.
Ethers are highly flammable and on exposure to air may form explosive peroxides.	
Ethers can be prepared by the reaction of halogenoalkanes with alkoxides.	
Ethers are used as solvents since they are relatively inert chemically and will dissolve many organic compounds.	
(iii) Aldehydes, ketones and carboxylic acids The following physical properties of aldehydes and ketones can be explained in terms of dipole-dipole attractions and/or hydrogen bonding:	
1. higher boiling points than corresponding alkanes 2. lower boiling points than corresponding alcohols 3. miscibility of lower members with water.	Compare boiling points of various aldehydes, ketones, carboxylic acids, alkanes and alcohols. Investigate miscibility with water.

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Tollens' reagent or Fehling's solution can be used to distinguish between aldehydes and ketones. Aldehydes reduce the complexed silver(I) ion and the complexed copper(II) ion to silver and copper(I) oxide, respectively.	Distinguish an aldehyde from a ketone by heating with Fehling's solution or Tollens' reagent.
Aldehydes and ketones can be reduced to primary and secondary alcohols, respectively, by reaction with lithium aluminium hydride in ether.	
Aldehydes and ketones undergo: 1. nucleophilic addition with HCN to form cyanohydrins which can be hydrolysed to hydroxy carboxylic acids. 2. nucleophilic addition-elimination with hydrazine, 2,4-dinitrophenylhydrazine to form hydrazones and 2,4-dinitrophenylhydrazones respectively.	
These nucleophilic addition-elimination reactions are also described as condensation since water is formed in the process.	
The melting points of the resulting 2,4-dinitrophenylhydrazones are used to identify unknown aldehydes and ketones.	*Identification by derivative formation.*
Aldehydes are generally more reactive than ketones because the presence of two alkyl groups in ketones hinders nucleophilic attack and reduces the partial positive charge on the carbonyl carbon atom.	Research uses of aldehydes and ketones.
In pure carboxylic acids hydrogen bonding produces dimers thus explaining the relatively high boiling points. Dimerisation does not occur in aqueous solution.	

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Carboxylic acid molecules also form hydrogen bonds with water molecules thus explaining the appreciable solubility of the lower carboxylic acids in water. As the chain length increases water solubility decreases.	
Carboxylic acids are weak acids. Their slight dissociation in water can be explained by the stability of the carboxylate ion caused by electron delocalisation.	Measure pH of equimolar solutions of methanoic, ethanoic and propanoic acids.
Carboxylic acids can be prepared by: 1. oxidising primary alcohols and aldehydes 2. hydrolysing nitriles, esters or amides.	Hydrolyse methyl salicylate. *Preparation of benzoic acid by hydrolysis of ethyl benzoate.*
Reactions of carboxylic acids include: 1. formation of salts by reactions with metals, carbonates and alkalis 2. condensation reactions with alcohols to form esters 3. reaction with ammonia or amines and subsequent heating of the ammonium salt to form amides 4. reduction with lithium aluminium hydride to form primary alcohols.	
(iv) Amines Amines are named according to IUPAC rules.	
Amines are organic derivatives of ammonia and can be classified as primary, secondary or tertiary.	
Primary and secondary amines, but not tertiary amines, associate by hydrogen bonding and as a result have higher boiling points than isomeric tertiary amines and alkanes with comparable relative formula masses.	Compare boiling point data.

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Amine molecules can hydrogen-bond with water molecules thus explaining the appreciable solubility of the lower amines in water.	
The nitrogen atom in amines has a lone pair of electrons which can accept a proton from water, producing hydroxide ions. Amines are weak bases.	Test pH of solutions of amines and ammonia.
Amines react with aqueous mineral or carboxylic acids to form salts.	Neutralise solutions of amines with mineral acids.
(v) Aromatics Bonding in benzene can be described in terms of sp^2 hybridisation, sigma and pi bonds, and electron delocalisation.	
Benzene is the simplest aromatic hydrocarbon and its unexpected stability can be attributed to the presence of delocalised electrons.	
Most reactions of benzene involve attack of an electrophile on the cloud of delocalised electrons, that is electrophilic substitution.	
Benzene resists addition reactions but undergoes electrophilic substitution reactions. These include: 1. chlorination and bromination to produce chlorobenzene and bromobenzene 2. nitration to produce nitrobenzene 3. sulphonation to produce benzene sulphonic acid 4. alkylation to produce alkylbenzenes.	Test methylbenzene (toluene) for unsaturation.

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CONTENT STATEMENTS	SUGGESTED ACTIVITIES
The presence of delocalised electrons in the phenyl group can be used to explain:	
1. the stronger acidic nature of phenol compared to aliphatic alcohols 2. the weaker basic nature of the aromatic amine, aminobenzene (aniline), compared with aliphatic amines.	Test pH of solutions of phenol and simple aliphatic alcohols. Test pH of solutions of aniline, simple aliphatic amines and ammonia.
(c) Stereoisomerism Stereoisomers have identical molecular formulae and the atoms are bonded together in the same order but the arrangement of the atoms in space is different, making them non-superimposable.	
Geometric isomerism Geometric isomerism is one type of stereoisomerism and can arise due to the lack of free rotation around a bond, frequently a carbon–carbon double bond.	Make models of geometric isomers.
Geometric isomers are labelled *cis* and *trans* according to whether the substituent groups are on the same side or on different sides of the carbon-carbon double bond.	
Geometric isomers display differences in some physical properties.	Compare melting points and densities of *cis*-but-2-enedioic acid and *trans*-but-2-enedioic acid.
Geometric isomerism can also influence chemical properties, for example *cis*-but-2-enedioic acid is more readily dehydrated than *trans*-but-2-enedioic acid.	Study examples of relevance of geometric isomerism in consumer products, eg, the health issues associated with trans fatty acids.

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Optical isomerism Optical isomers are non-superimposable mirror images of each other and are said to be chiral.	Make models of optical isomers.
Optical isomerism can occur in substances in which four different groups are arranged around a carbon atom.	Demonstrate the rotation of plane polarised light by optical isomers.
Optical isomers have identical physical and chemical properties, except when they are in a chiral environment, but they have an opposite effect on plane polarised light and are said to be optically active.	Consider examples of properties and activity of optical isomers, eg, thalidomide.
Mixtures containing equal amounts of both optical isomers are optically inactive.	
In biological systems only one optical isomer of each organic compound is usually present.	
(d) Structural analysis **(i) Elemental microanalysis and mass spectrometry** *Elemental microanalysis* Elemental microanalysis (combustion analysis) can be used to determine the masses of C, H, S and N in a sample of an organic compound in order to find the empirical formula.	View Modern Chemical Techniques video (Royal Society of Chemistry). Calculate empirical formulae from results of elemental microanalysis.
Other elements in the organic compound have to be determined by other methods.	

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Mass spectrometry Mass spectrometry can be used to determine the accurate molecular mass and structural features of an organic compound. A conventional mass spectrometer functions in the following manner: • The sample is firstly vaporised and then ionised by being bombarded with electrons • Fragmentation can occur when the energy available is greater than the molecular ionisation energy • The parent ion and ion fragments are accelerated by an electric field and then deflected by a magnetic field • The strength of the magnetic field is varied to enable the ions of all the different mass/charge ratios to be detected in turn. A mass spectrum is obtained. Organic compounds can be identified from the very accurate determination of the relative molecular masses of the parent ion and the ion fragments.	Study examples of simple mass spectra.
(ii) Infra-red and nuclear magnetic resonance spectroscopy and X-ray crystallography *Infra-red spectroscopy* Infra-red spectroscopy can be used to identify certain functional groups in an organic compound.	Examine and interpret infra-red spectra of some simple organic compounds. Use simple spectra to identify organic compounds.

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
Infra-red radiation causes parts of a molecule to vibrate. The wavelengths which are absorbed and cause the vibrations will depend on the type of chemical bond and the groups or atoms at the ends of these bonds. Infra-red radiation is passed through a sample of the organic compound and then to a detector which measures the intensity of the transmitted radiation at different wavelengths. Infra-red spectra are expressed in terms of wavenumber. The unit of measurement of wavenumber which is the reciprocal of wavelength, is cm^{-1}. *Nuclear magnetic resonance spectroscopy* Nuclear magnetic resonance spectroscopy (nmr) can give information about: 1. the different environments of hydrogen atoms in an organic molecule 2. how many hydrogen atoms there are in each of these environments. Hydrogen nuclei behave like tiny magnets and in a strong magnetic field some are aligned with the field (lower energy) while the rest are aligned against it (higher energy). Absorption of radiation in the radiofrequency region of the electromagnetic spectrum will cause the hydrogen nuclei to 'flip' from the lower energy alignment to the higher one. As they fall back from the higher to the lower level the emitted radiation is detected. In the nmr spectrum the peak position (chemical shift) is related to the environment of the proton. The area under the peak is related to the number of protons in that environment. The standard reference substance used in nmr spectroscopy is tetramethylsilane (TMS) which is assigned a chemical shift equal to zero.	Examine and interpret some simple nmr spectra of organic compounds. Read about the application of nmr in medical body scanners.

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CONTENT STATEMENTS	SUGGESTED ACTIVITIES
X-ray crystallography X-ray crystallography can be used to determine the precise three-dimensional structure of organic compounds.	
When a crystal of an organic compound is exposed to X-rays of a single wavelength, the atoms of the crystal act as a diffraction grating.	
Electron-density maps are produced from the positions and intensities of the ‘spots’ in the diffraction pattern.	Examine and interpret electron-density maps.
From the electron-density map the precise location of each atom in the molecule can be determined, and since heavier atoms have more electrons than lighter ones each atom in the molecule can be identified.	
Since a hydrogen atom has a low electron density it is not easily detected by X-rays.	
(e) Medicines Drugs are substances which alter the biochemical processes in the body and those which have a beneficial effect are called medicines.	
Historical development The first medicines were plant brews. Pharmacologically active compounds in plant extracts were identified. These compounds and derivatives of them were synthesised where practicable.	Find out about the historical development of other drugs derived from natural sources.
Aspirin is an example of a medicine developed in this way.	Find out about the historical development of aspirin. *Preparation of aspirin* *Aspirin determination*

CONTENT STATEMENTS	SUGGESTED ACTIVITIES
How a medicine functions Most medicines work by binding to receptors. Receptors are usually protein molecules that are either on the surface of cells where they interact with small biologically active molecules or are enzymes that catalyse chemical reactions (catalytic receptors). That structural fragment of the molecule which confers pharmacological activity on it is called the pharmacophore. The shape of the pharmacophore complements that of the receptor site, allowing it to fit into the receptor. The functional groups on both are correctly positioned to interact and bind the medicine to the receptor. By comparing the structures of medicines with similar pharmacological activity, the pharmacophore can be identified. Many medicines can be classified as agonists or as antagonists according to whether they enhance or block the body's natural responses. An agonist will produce a response like the body's natural active compound. An antagonist produces no response but prevents the action of the body's natural active compound.	Find out about: 1. salbutamol as an agonist for treatment of asthma 2. propranolol as an antagonist for treatment of heart conditions 3. sulphanilamides and penicillins as antibiotics which function as antagonists.

National Course Specification: course details (cont)

COURSE Chemistry (Advanced Higher)

ASSESSMENT

To gain the award of the course, the candidate must achieve all the component units of the course as well as the external assessment. External assessment will provide the basis for grading attainment in the course award.

When units are taken as component parts of a course, candidates will have the opportunity to demonstrate achievement beyond that required to attain each of the unit outcomes. This attainment may, where appropriate, be recorded and used to contribute towards course estimates and to provide evidence for appeals. Further information and advice on assessment can be seen in the Subject Guide or from the National Assessment Bank.

Further information on the key principles of assessment are provided in the paper *Assessment*, (HSDU, 1996) and in Managing Assessment (HSDU, 1998).

DETAILS OF INSTRUMENTS FOR EXTERNAL ASSESSMENT

External assessment will consist of the following two components:

Written examination (2 hours 30 minutes)	100 marks
Investigation Report	25 marks.

Written examination

The examination will consist of one paper, of 2 hours 30 minutes with a total allocation of 100 marks.

The examination will sample across the performance criteria associated with the three outcomes in each of the three content units. The detailed knowledge and understanding required for each unit is listed in the course content.

The paper will be divided into the following sections:

Section A	Fixed-response questions	40 marks
Section B	Extended-answer questions	60 marks.

Section A will be made up of 40 multiple-choice questions.

In Section B approximately 6 marks will be allocated to questions which draw on the candidates' experience of the prescribed practical activities.

Of the 100 marks in the written paper, between 50 and 55 marks will be allocated to the assessment of knowledge and understanding and between 45 and 50 marks will be allocated to the assessment of problem solving.

Up to 10 marks over the paper can be allocated to questions based on the content of Higher Chemistry, with assessment at a level appropriate to Advanced Higher.

Candidates will be expected to answer all questions.

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Investigation report

The final investigation report will be worth 20% of the total marks. The investigation report will be based on the work carried out in the component unit, *Chemical Investigation (AH).*

A total of 25 marks will be allocated to the investigation report which should be around 2000-2500 words in length excluding contents pages, indexes, tables, graphs, etc.

The investigation report will be externally assessed using the following assessment categories:

(a) Introduction (4 marks)
(b) Procedures (6 marks)
(c) Results (5 marks)
(d) Discussion (7 marks)
(e) Presentation (3 marks).

It is expected that approximately 10 hours of the 'additional 40 hours will be required for the candidate to complete the report for the course award.

Grade

The grade awarded for the course will depend on the total marks obtained by the candidate (out of 125) for the written question paper and the investigation report. The certificate will record an award for overall attainment.

GRADE DESCRIPTIONS

Grade C

Candidates at Grade C will have demonstrated success in achieving the component units of the course. In the course assessment candidates achieving a Grade C will have demonstrated an overall satisfactory level of performance by:

- retaining knowledge and understanding over a long period of time
- integrating knowledge and understanding across the three component units of the course
- displaying problem solving skills in less familiar contexts
- selecting, analysing and presenting information collected through experimental and observational work in the investigation
- writing in a scientific manner which reveals the significance of the chemistry relating to the investigation.

Grade A

In addition, candidates achieving a Grade A will have demonstrated a high overall level of performance by:

- retaining knowledge and understanding over a long period of time
- showing a deeper level of knowledge and understanding
- integrating knowledge and understanding across the three component units of the course
- displaying problem solving skills in less familiar and more complex contexts
- showing particular proficiency in selecting, analysing and presenting information collected through experimental and observational work in the investigation

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- showing particular proficiency in writing in a scientific manner which reveals the significance of the findings of the investigation by analysing and interpreting the results in a critical and scientific manner and demonstrating knowledge and understanding of the chemistry relating to the investigation.

DETAILS OF THE INSTRUMENTS FOR INTERNAL ASSESSMENT

Units 1, 2 and 3

Outcomes 1 and 2

For each unit, Outcomes 1 and 2 will be assessed by a single holistic closed-book test. The ratio of marks allocated to Outcomes 1 and 2 will be 3:2.

In each test, all of the performance criteria and aspects of evidence requirements for Outcome 1 and all of the specified performance criteria for Outcome 2, will be assessed.

Outcome 3

Candidates are required to produce one report on an experiment covering all of the performance criteria and related to Advanced Higher Chemistry, ie the report must be based on any one of the prescribed practical activities listed in the table below:

ACTIVITY	UNIT
Preparation of Potassium Trioxalatoferrate(III)	1
Colorimetric Determination of Manganese in Steel	1
Complexometric Determination of Nickel using EDTA	2
Gravimetric Determination of Water in Hydrated Barium Chloride	2
Determination of a Partition Coefficient	2
Verification of a Thermodynamic Prediction	2
Kinetics of the Acid-Catalysed Propanone/Iodine Reaction	2
Preparation of Cyclohexene	3
Identification by Derivative Formation	3
Preparation of Benzoic Acid by Hydrolysis of Ethyl Benzoate	3
Preparation of Aspirin	3
Aspirin Determination	3

National Course Specification: course details (cont)

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Investigation Unit

Outcomes 1 and 2

Candidates are required to provide a record of their investigation covering all of the performance criteria for Outcomes 1 and 2.

APPROACHES TO LEARNING AND TEACHING

Candidates following the Advanced Higher course may have encountered a variety of teaching approaches ranging from teacher or lecturer exposition to highly structured resource-based individualised learning. Many candidates at Advanced Higher will progress to higher education where they may have to take an increased responsibility for the detailed content of what they learn. The Advanced Higher course should encourage candidates to develop the skills of independent study which will be necessary in higher education. These skills are valuable not only in higher education but also in any activity where the assimilation and presentation of detailed and complex information is required.

Candidates may benefit from experiencing an increasing emphasis on formal lecture methods during the course through which they can develop the skills necessary for independent study. These skills include the ability to amplify lecture notes and to build up understanding by reflective study and by reference to textbooks and other published material. Also valuable is an awareness of possible limitations of published material. Suitably designed resource-based materials can also contribute to the development of these skills.

Where possible, chemical facts and theory should be taught in contexts which have as their starting points real-life situations and applications. Examples can be given which demonstrate the distinction between chemical fact and theory.

Practical work is important in developing the candidate’s practical skills in chemistry and also has a role in emphasising the fact that chemistry is an experimental science. Practicals involving analysis and synthesis can illustrate the real-life applications of chemistry.

The chemical investigation, which is part of the external assessment for the course, is designed to encourage the development of many of the skills of independent study outlined above. It can also make a valuable contribution to the candidate’s awareness of the possible limitations of chemical theory and/or experimental evidence.

The additional 40 hours

- Approximately ten hours of the additional 40 hours can be used for completion of the report of the chemical investigation for the external assessment.
- Another portion of the additional 40 hours should be used to allow candidates to develop the ability to integrate the knowledge, understanding, problem solving and practical skills acquired through the study of the different component units.
- The remaining time within the additional 40 hours can be used for consolidation, remediation and preparation for the external examination.

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SPECIAL NEEDS

This course specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment Arrangements* (SQA, 2001).

SCOTTISH QUALIFICATIONS AUTHORITY

National Unit Specification: general information

UNIT Electronic Structure and the Periodic Table (Advanced Higher)

NUMBER D072 13

COURSE Chemistry (Advanced Higher)

SUMMARY

This unit is designed to develop the candidate's knowledge firstly of electronic structure and its relation to the Periodic Table, secondly of chemical bonding, and thirdly of some chemistry of the Periodic Table including that of the transition metals. The unit builds on some of the content of the Higher Chemistry unit *Energy Matters*. The unit can provide opportunities for the candidate to develop problem solving abilities and practical skills in the context of the subject matter covered.

OUTCOMES

1 Demonstrate knowledge and understanding related to *Electronic Structure and the Periodic Table*.
2 Solve problems related to *Electronic Structure and the Periodic Table*.
3 Collect and analyse information related to *Advanced Higher Chemistry* obtained by experiment.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates will normally be expected to have attained one of the following:

- Higher Chemistry or its component units
- equivalent.

In particular a good knowledge of the Higher Chemistry unit *Energy Matters* is recommended.

Administrative Information

Superclass: RD

Publication date: June 2002

Source: Scottish Qualifications Authority

Version: 04

National Unit Specification: general information (cont)

UNIT Electronic Structure and the Periodic Table (Advanced Higher)

CREDIT VALUE

0.5 credits at Advanced Higher.

CORE SKILLS

Core skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001)

National Unit Specification: statement of standards

UNIT Electronic Structure and the Periodic Table (Advanced Higher)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Demonstrate knowledge and understanding related to *Electronic Structure and the Periodic Table.*

Performance criteria

(a) Knowledge and understanding of electronic structure is clearly shown in appropriate ways.
(b) Knowledge and understanding of chemical bonding is clearly shown in appropriate ways.
(c) Knowledge and understanding of some chemistry of the Periodic Table is clearly shown in appropriate ways.

Evidence requirements

Evidence of an appropriate achievement from a closed-book test with items covering all of the following aspects of the above performance criteria.

Knowledge and understanding of electronic structure

(i) Electromagnetic spectrum and associated calculations
(ii) Electronic configuration and the Periodic Table
(iii) Spectroscopy.

Knowledge and understanding of chemical bonding

(i) Covalent bonding
(ii) Shapes of molecules and polyatomic ions
(iii) Ionic lattices, superconductors and semiconductors.

Knowledge and understanding of some chemistry of the Periodic Table

(i) The second and third short periods: oxides, chlorides and hydrides
(ii) Electronic configuration and oxidation states of transition metals
(iii) Transition metal complexes.

National Unit Specification: statement of standards (cont)

UNIT Electronic Structure and the Periodic Table (Advanced Higher)

OUTCOME 2

Solve problems related to *Electronic Structure and the Periodic Table*.

Performance criteria

(b) Information is accurately processed using calculations where appropriate.
(c) Conclusions drawn are valid and explanations given are supported by evidence.
(e) Predictions and generalisations made are based on available evidence.

Note: The lettering system for PCs is common to all units in the Advanced Higher Chemistry course. Not all of the PCs feature in all of the units. For example, PC (d) does NOT feature in this unit, although it does feature in other units in the course.

Evidence requirements

Evidence of an appropriate level of achievement from a closed-book test with items covering all the above performance criteria.

OUTCOME 3

Collect and analyse information related to *Advanced Higher Chemistry* obtained by experiment.

Performance criteria

(a) The information is collected by active participation in the experiment.
(b) The experimental procedures are described accurately.
(c) Relevant measurements and observations are recorded in an appropriate format.
(d) Recorded experimental information is analysed and presented in an appropriate format.
(e) Conclusions drawn are valid.
(f) The experimental procedures are evaluated with supporting argument.

Evidence requirements

A report of one experimental activity is required covering the above performance criteria and related to one of the experiments specified in the contents and notes for Advanced Higher Chemistry.

The report must be the individual work of the candidate and based on an experiment in which the candidate has been involved. Depending on the activity, the collection of the information may be group work.

National Unit Specification: support notes

UNIT Electronic Structure and the Periodic Table (Advanced Higher)

This part of the unit specification is offered as guidance. The support notes are not mandatory.

While the time allocated to this unit is at the discretion of the centre, the notional design length is 20 hours.

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

The recommended content for this unit is specified by the Content Statements listed in the Course Details of the Course Specification. These 'Content Statements' are subdivided according to the Performance Criteria and Evidence Requirements for Outcome 1. Problem solving abilities should be developed in the context of the Content statements. Practical skills should be developed using the Prescribed Practical Activities listed for this unit in the course specification and, where appropriate, other suitable experiments related to the 'Content Statements'.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

A variety of teaching and learning methods should be used for this unit ranging from lecture to independent study. These methods should aim to develop in the candidate the skills of independent study that are required in Higher Education. Practical work is an important part of this unit and should be used where appropriate to illustrate the theory content. When possible, the knowledge and understanding content, the problem solving abilities and the practical skills should be related to topical applications and situations.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Outcomes 1 and 2

It is recommended that Outcomes 1 and 2 be assessed by an integrated end of unit test covering all of the performance criteria for knowledge and understanding and problem solving.

For Outcome 1, each of the subdivisions specified in the Evidence Requirements associated with the Performance Criteria should be assessed. The questions should sample the Content statements listed for each Evidence Requirement subdivision in the course specification. The subdivisions are headed in bold type. The same question can be used to assess more than one Evidence Requirement subdivision.

For Outcome 2 questions should be set where appropriate in the context of the content for Outcome 1. The same question can be used to provide evidence for Outcome 1 and Outcome 2 components.

Appropriate assessment items are available from the National Assessment Bank.

Outcome 3

Opportunities to generate evidence for attainment at Outcome 3 will arise during the practical work related to the prescribed practical activities.

Related to PC (a), the teacher/lecturer checks by observation that the candidate has taken an active part in the collection of information by experiment.

Candidates should provide a structured report with an appropriate title. The report should relate to the performance criteria as follows:

(b) As experiments will follow a given procedure or method there is no need for a detailed description. The procedure, or the steps in the procedure, should be described briefly in outline. The impersonal passive voice should be used. The following should be used as appropriate:

- aim of the experiment
- background theory of the experiment
- a labelled diagram, description of apparatus, instruments used
- how measurements were taken or observations made
- comments on safety.

(c) Readings or observations (raw data) should be recorded using the following, as appropriate:

- a table with correct headings and appropriate units
- a table with readings/observations entered correctly
- a statement of results.

(d) Readings or observations (raw data) should be analysed/presented using the following, as appropriate:

- a table with suitable headings and units
- a table with ascending or descending independent variable
- a table showing appropriate computations
- a correct calculation
- a graph with independent and dependent variables plotted on horizontal and vertical axes respectively
- a graph with suitable scales and axes labelled with quantities and units
- a graph with data correctly plotted with a line or curve of best fit.

(e) Conclusions should contain, as appropriate:

- the overall pattern to readings
- the trends in analysed information or results
- the connection between variables
- an analysis of the observations
- the findings from completed calculations.

(f) The experimental procedures should be evaluated with supporting argument by including reference to one of the following:

- effectiveness of procedures
- control of variables
- limitations of equipment
- possible improvements
- possible sources of error.

The bullet points under each performance criterion give an indication of what should be addressed to achieve a pass. The relevance of the bullet points will vary according to the experiment. These bullet points are intended as helpful guidance. The decision of pass or fail is to be made by the professional judgement of the presenting centre (subject to moderation) against the performance criteria.

Redrafting

It is appropriate to support candidates in producing a report to meet the performance criteria. Redrafting of reports after necessary supportive criticism is to be encouraged both as part of the learning and teaching process and to produce evidence for assessment. Redrafting is only required for the specific performance criteria identified in need of further attention, ie the entire report does not require to be rewritten.

Conditions required to complete the report

Candidates may complete their reports outwith class time provided reasonable measures are taken to ensure that the report is the individual work of the candidate.

Teachers and lecturers may wish candidates to write up reports under their direct supervision so that they can provide appropriate advice and support. However, they may feel confident that any redrafting required need not be undertaken under such close supervision as it will be evident in the candidate’s response that it is his or her unaided work. Under such circumstances it would be acceptable for such redrafting to take place outwith class time.

Use of IT

Candidates may, if they wish, present their reports in a word-processed format. Candidate may use Excel or any other suitable data analysis software when tackling Outcome 3. However, candidates must not be given a spreadsheet with pre-prepared column headings or formula since they are being assessed on their ability to enter quantities and units into a table and to make decisions about appropriate scales and labels on graph axes. Excel may also be used to analyse large amounts of experimental data and to plot graphs containing error bars.

Transfer of evidence

A report on an Advanced Higher Unit 2 or Unit 3 prescribed practical activity may be used as evidence to meet the Outcome 3 requirements of this unit.

Candidates, who are repeating a year, may use evidence of an appropriate standard generated in a previous year.

UNIT Electronic Structure and the Periodic Table (Advanced Higher)

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment Arrangements* (SQA, 2001).

National Unit Specification: general information

UNIT Principles of Chemical Reactions (Advanced Higher)

NUMBER D073 13

COURSE Chemistry (Advanced Higher)

SUMMARY

This unit aims to develop the candidate's knowledge and understanding of some of the major concepts used to explain chemical behaviour. Within the context of these concepts the unit seeks also to develop the candidate's problem solving abilities and practical skills.

OUTCOMES

1. Demonstrate knowledge and understanding related to the *Principles of Chemical Reactions*.
2. Solve problems related to *Principles of Chemical Reactions.*
3. Collect and analyse information related to *Advanced Higher Chemistry* obtained by experiment.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates will normally be expected to have attained one of the following:

- Higher Chemistry or its component units
- equivalent.

In particular, candidates would benefit from a clear understanding of the Higher Chemistry units *Energy Matters* and *Chemical Reactions*.

Administrative Information

Superclass: RD

Publication date: June 2002

Source: Scottish Qualifications Authority

Version: 04

National Unit Specification: general information (cont)

UNIT Principles of Chemical Reactions (Advanced Higher)

CREDIT VALUE

1 credit at Advanced Higher.

CORE SKILLS

Core skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001)

National Unit Specification: statement of standards

UNIT Principles of Chemical Reactions (Advanced Higher)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Demonstrate knowledge and understanding related to *Principles of Chemical Reactions*.

Performance criteria

(a) Knowledge and understanding of stoichiometry is clearly shown in appropriate ways.
(b) Knowledge and understanding of chemical equilibrium is clearly shown in appropriate ways.
(c) Knowledge and understanding of thermochemistry is clearly shown in appropriate ways.
(d) Knowledge and understanding of reaction feasibility is clearly shown in appropriate ways.
(e) Knowledge and understanding of electrochemistry is clearly shown in appropriate ways.
(f) Knowledge and understanding of kinetics is clearly shown in appropriate ways.

Evidence requirements

Evidence of an appropriate achievement from a closed-book test with items covering all of the following aspects of the above performance criteria.

Knowledge and understanding of stoichiometry

Further detail not required

Knowledge and understanding of chemical equilibrium

(i) Reactions at equilibrium
(ii) Equilibria between different phases
(iii) Equilibria involving ions

Knowledge and understanding of thermochemistry

(i) Hess's Law
(ii) Bond enthalpies
(iii) Hess's Law applied to ionic substances

Knowledge and understanding of reaction feasibility

(i) Entropy
(ii) Free energy

Knowledge and understanding of electrochemistry

Further detail not required

Knowledge and understanding of kinetics

Further detail not required

National Unit Specification: statement of standards (cont)

UNIT Principles of Chemical Reactions (Advanced Higher)

OUTCOME 2

Solve problems related to the *Principles of Chemical Reactions*.

Performance criteria

(b) Information is accurately processed using calculations where appropriate.
(c) Conclusions drawn are valid and explanations given are supported by evidence.
(e) Predictions and generalisations made are based on available evidence.

Note: The lettering system for PCs is common to all units in the Advanced Higher Chemistry course. Not all of the PCs feature in all of the units. For example, PC (d) does NOT feature in this unit, although it does feature in other units in the course.

Evidence requirements

Evidence of an appropriate level of achievement from a closed-book test with items covering all the above performance criteria.

OUTCOME 3

Collect and analyse information related to *Advanced Higher Chemistry* obtained by experiment.

Performance criteria

(a) The information is collected by active participation in the experiment.
(b) The experimental procedures are described accurately.
(c) Relevant measurements and observations are recorded in an appropriate format.
(d) Recorded experimental information is analysed and presented in an appropriate format.
(e) Conclusions drawn are valid.
(f) The experimental procedures are evaluated with supporting argument.

Evidence requirements

A report of one experimental activity is required covering all of the above performance criteria and related to one of the experiments specified in the contents and notes for Advanced Higher Chemistry.

The report must be the individual work of the candidate and based on an experiment in which the candidate has been involved. Depending on the activity, the collection of the information may be group work.

National Unit Specification: support notes

UNIT Principles of Chemical Reactions (Advanced Higher)

This part of the unit specification is offered as guidance. The support notes are not mandatory.

While the time allocated to this unit is at the discretion of the centre, the notional design length is 40 hours.

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

The recommended content for this unit is specified by the Content Statements listed in the Course Details of the Course Specification. These 'Content Statements' are subdivided according to the Performance Criteria and Evidence Requirements for Outcome 1. Problem solving abilities should be developed in the context of the Content statements. Practical skills should be developed using the Prescribed Practical Activities listed for this unit in the course specification and, where appropriate, other experiments related to the 'Content Statements'.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

A variety of teaching and learning methods should be used for this unit ranging from lecture to independent study. These methods should aim to develop in the candidate the skills of independent study that are required in Higher Education. Practical work is an important part of this unit and should be used where appropriate to illustrate the theory content. When possible, the knowledge and understanding content, the problem solving abilities and the practical skills should be related to topical applications and situations.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Outcomes 1 and 2

It is recommended that Outcomes 1 and 2 be assessed by an integrated end of unit test covering all of the performance criteria for knowledge and understanding and problem solving.

For Outcome 1, each of the subdivisions specified in the Evidence Requirements associated with the Performance Criteria should be assessed. The questions should sample the Content statements listed for each Evidence Requirement subdivision in the course specification. The subdivisions are headed in bold type. The same question can be used to assess more than one Evidence Requirement subdivision.

For Outcome 2 questions should be set where appropriate in the context of the content for Outcome 1. The same question can be used to provide evidence for Outcome 1 and Outcome 2 components.

Appropriate items are available from the National Assessment Bank.

Outcome 3

Opportunities to generate evidence for attainment at Outcome 3 will arise during the practical work related to the prescribed practical activities.

Related to PC (a), the teacher/lecturer checks by observation that the candidate has taken an active part in the collection of information by experiment.

Candidates should provide a structured report with an appropriate title. The report should relate to the performance criteria as follows:

(b) As experiments will follow a given procedure or method there is no need for a detailed description. The procedure, or the steps in the procedure, should be described briefly in outline. The impersonal passive voice should be used. The following should be used as appropriate:

- aim of the experiment
- background theory of the experiment
- a labelled diagram, description of apparatus, instruments used
- how measurements were taken or observations made
- comments on safety.

(c) Readings or observations (raw data) should be recorded using the following, as appropriate:

- a table with correct headings and appropriate units
- a table with readings/observations entered correctly
- a statement of results.

(d) Readings or observations (raw data) should be analysed/presented using the following, as appropriate:

- a table with suitable headings and units
- a table with ascending or descending independent variable
- a table showing appropriate computations
- a correct calculation
- a graph with independent and dependent variables plotted on horizontal and vertical axes respectively
- a graph with suitable scales and axes labelled with quantities and units
- a graph with data correctly plotted with a line or curve of best fit.

(e) Conclusions should contain, as appropriate:

- the overall pattern to readings
- the trends in analysed information or results
- the connection between variables
- an analysis of the observations
- the findings from completed calculations.

(f) The experimental procedures should be evaluated with supporting argument by including reference to one of the following:

- effectiveness of procedures
- control of variables
- limitations of equipment
- possible improvements
- possible sources of error.

The bullet points under each performance criterion give an indication of what should be addressed to achieve a pass. The relevance of the bullet points will vary according to the experiment. These bullet points are intended as helpful guidance. The decision of pass or fail is to be made by the professional judgement of the presenting centre (subject to moderation) against the performance criteria.

Redrafting

It is appropriate to support candidates in producing a report to meet the performance criteria. Redrafting of reports after necessary supportive criticism is to be encouraged both as part of the learning and teaching process and to produce evidence for assessment. Redrafting is only required for the specific performance criteria identified in need of further attention, ie the entire report does not required to be rewritten.

Conditions required to complete the report

Candidates may complete their reports outwith class time provided reasonable measures are taken to ensure that the report is the individual work of the candidate.

Teachers and lecturers may wish candidates to write up reports under their direct supervision so that they can provide appropriate advice and support. However, they may feel confident that any redrafting required need not be undertaken under such close supervision as it will be evident in the candidate’s response that it is his or her unaided work. Under such circumstances it would be acceptable for such redrafting to take place outwith class time.

Use of IT

Candidates may, if they wish, present their reports in a word-processed format. Candidates may use Excel or any other suitable data analysis software when tackling Outcome 3. However, candidates must not be given a spreadsheet with pre-prepared column headings or formula since they are being assessed on their ability to enter quantities and units into a table and to make decisions about appropriate scales and labels on graph axes. Excel may also be used to analyse large amounts of experimental data and to plot graphs containing error bars.

Transfer of evidence

A report on an Advanced Higher Unit 2 or Unit 3 prescribed practical activity may be used as evidence to meet the Outcome 3 requirements of this unit.

Candidates, who are repeating a year, may use evidence of an appropriate standard generated in a previous year.

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment Arrangements* (SQA, 2001).

National Unit Specification: general information

UNIT Organic Chemistry (Advanced Higher)

NUMBER D074 13

COURSE Chemistry (Advanced Higher)

SUMMARY

This unit aims to develop the candidate's knowledge and understanding of some of organic chemistry. Within the context of organic chemistry the unit seeks also to develop the candidate's problem solving abilities and practical skills.

OUTCOMES

1. Demonstrate knowledge and understanding related to *Organic Chemistry*.
2. Solve problems related to *Organic Chemistry*.
3. Collect and analyse information related to *Advanced Higher Chemistry* obtained by experiment.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates will normally be expected to have attained one of the following awards:

- Higher Chemistry or its component units
- equivalent.

In particular, candidates would benefit from a clear understanding of the Higher Chemistry unit *World of Carbon*.

Administrative Information

Superclass: RD

Publication date: June 2002

Source: Scottish Qualifications Authority

Version: 04

National Unit Specification: general information (cont)

UNIT Organic Chemistry (Advanced Higher)

CREDIT VALUE

1 credit at Advanced Higher.

CORE SKILLS

Core skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001)

National Unit Specification: statement of standards

UNIT Organic Chemistry (Advanced Higher)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Demonstrate knowledge and understanding related to *Organic Chemistry*.

Performance criteria

(a) Knowledge and understanding of some permeating aspects of organic chemistry is clearly shown in appropriate ways.
(b) Knowledge and understanding of systematic organic chemistry is clearly shown in appropriate ways.
(c) Knowledge and understanding of stereoisomerism is clearly shown in appropriate ways.
(d) Knowledge and understanding of structural analysis is clearly shown in appropriate ways.
(e) Knowledge and understanding of medicines is clearly shown in appropriate ways.

Evidence requirements

Evidence of an appropriate achievement from a closed-book test with items covering all of the following aspects of the above performance criteria.

Knowledge and understanding of some permeating aspects of organic chemistry

(i) Reaction types
(ii) Reaction mechanisms
(iii) Physical properties

Knowledge and understanding of systematic organic chemistry

(i) Hydrocarbons and halogenoalkanes
(ii) Alcohols and ethers
(iii) Aldehydes, ketones and carboxylic acids
(iv) Amines
(v) Aromatics

Knowledge and understanding of stereoisomerism

Further detail not required

Knowledge and understanding of structural analysis

(i) Elemental microanalysis and mass spectrometry
(ii) Infra-red and nuclear magnetic resonance spectroscopy, and X-ray crystallography

Knowledge and understanding of medicines

Further detail not required

National Unit Specification: statement of standards (cont)

UNIT Organic Chemistry (Advanced Higher)

OUTCOME 2

Solve problems related to *Organic Chemistry*.

Performance criteria

(c) Conclusions drawn are valid and explanations given are supported by evidence.
(d) Experimental procedures are planned, designed and evaluated in an appropriate way.
(e) Predictions and generalisations made are based on available evidence.

Note: The lettering system for PCs is common to all units in the Advanced Higher Chemistry course. Not all of the PCs feature in all of the units. For example, PC (b) does NOT feature in this unit, although it does feature in other units in the course.

Evidence requirements

Evidence of an appropriate level of achievement from a closed-book test with items covering all the above performance criteria.

OUTCOME 3

Collect and analyse information related to *Advanced Higher Chemistry* obtained by experiment.

Performance criteria

(a) The information is collected by active participation in the experiment.
(b) The experimental procedures are described accurately.
(c) Relevant measurements and observations are recorded in an appropriate format.
(d) Recorded experimental information is analysed and presented in an appropriate format.
(e) Conclusions drawn are valid.
(f) The experimental procedures are evaluated with supporting argument.

Evidence requirements

A report of one experimental activity is required covering all of the above performance criteria and related to one of the experiments specified in the contents and notes for Advanced Higher Chemistry.

The report must be the individual work of the candidate and based on an experiment in which the candidate has been involved. Depending on the activity, the collection of the information may be group work.

National Unit Specification: support notes

UNIT Organic Chemistry (Advanced Higher)

This part of the unit specification is offered as guidance. The support notes are not mandatory.

While the time allocated to this unit is at the discretion of the centre, the notional design length is 40 hours.

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

The recommended content for this unit is specified by the Content Statements listed in the Course Details of the Course Specification. These 'Content Statements' are subdivided according to the Performance Criteria and Evidence Requirements for Outcome 1. Problem solving abilities should be developed in the context of the 'Content Statements'. Practical skills should be developed using the Prescribed Practical Activities listed for this unit in the course specification and where appropriate other experiments related to the 'Content Statements'.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

A variety of teaching and learning methods should be used for this unit ranging from lecture to independent study. These methods should aim to develop in the candidate the skills of independent study that are required in Higher Education. Practical work is an important part of this unit and should be used where appropriate to illustrate the theory content. When possible, the knowledge and understanding content, the problem solving abilities and the practical skills should be related to topical applications and situations.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Outcomes 1 and 2

It is recommended that Outcomes 1 and 2 be assessed by an integrated end of unit test covering all of the performance criteria for knowledge and understanding and problem solving.

For Outcome 1, each of the subdivisions specified in the Evidence Requirements associated with the Performance Criteria should be assessed. The questions should sample the Content statements listed for each Evidence Requirement subdivision in the course specification. The subdivisions are headed in bold type. The same question can be used to assess more than one Evidence Requirement subdivision.

For Outcome 2 questions should be set where appropriate in the context of the content for Outcome 1. The same question can be used to provide evidence for Outcome 1 and Outcome 2 components.

Appropriate items are available from the National Assessment Bank.

National Unit Specification: support notes (cont)

UNIT Organic Chemistry (Advanced Higher)

Outcome 3

Opportunities to generate evidence for attainment at Outcome 3 will arise during the practical work related to the prescribed practical activities.

Related to PC (a), the teacher/lecturer checks by observation that the candidate has taken an active part in the collection of information by experiment.

Candidates should provide a structured report with an appropriate title. The report should relate to the performance criteria as follows:

(b) As experiments will follow a given procedure or method there is no need for a detailed description. The procedure, or the steps in the procedure, should be described briefly in outline. The impersonal passive voice should be used. The following should be used as appropriate:

- aim of the experiment
- background theory of the experiment
- a labelled diagram, description of apparatus, instruments used
- how measurements were taken or observations made
- comments on safety.

(c) Readings or observations (raw data) should be recorded using the following, as appropriate:

- a table with correct headings and appropriate units
- a table with readings/observations entered correctly
- a statement of results.

(d) Readings or observations (raw data) should be analysed/presented using the following, as appropriate:

- a table with suitable headings and units
- a table with ascending or descending independent variable
- a table showing appropriate computations
- a correct calculation
- a graph with independent and dependent variables plotted on horizontal and vertical axes respectively
- a graph with suitable scales and axes labelled with quantities and units
- a graph with data correctly plotted with a line or curve of best fit.

(e) Conclusions should contain, as appropriate:

- the overall pattern to readings
- the trends in analysed information or results
- the connection between variables
- an analysis of the observations
- the findings from completed calculations.

(f) The experimental procedures should be evaluated with supporting argument by including reference to one of the following:

- effectiveness of procedures
- control of variables
- limitations of equipment
- possible improvements
- possible sources of error.

The bullet points under each performance criterion give an indication of what should be addressed to achieve a pass. The relevance of the bullet points will vary according to the experiment. These bullet points are intended as helpful guidance. The decision of pass or fail is to be made by the professional judgement of the presenting centre (subject to moderation) against the performance criteria.

Redrafting

It is appropriate to support candidates in producing a report to meet the performance criteria. Redrafting of reports after necessary supportive criticism is to be encouraged both as part of the learning and teaching process and to produce evidence for assessment. Redrafting is only required for the specific performance criteria identified in need of further attention, ie the entire report does not require to be rewritten.

Conditions required to complete the report

Candidates may complete their reports outwith class time provided reasonable measures are taken to ensure that the report is the individual work of the candidate.

Teachers and lecturers may wish candidates to write up reports under their direct supervision so that they can provide appropriate advice and support. However, they may feel confident that any redrafting required need not be undertaken under such close supervision as it will be evident in the candidate’s response that it is his or her unaided work. Under such circumstances it would be acceptable for such redrafting to take place outwith class time.

Use of IT

Candidates, may, if they wish, present their reports in a word-processed format. Candidates may use Excel or any other suitable data analysis software when tackling Outcome 3. However, candidates must not be given a spreadsheet with pre-prepared column headings or formula since they are being assessed on their ability to enter quantities and units into a table and to make decisions about appropriate scales and labels on graph axes. Excel may also be used to analyse large amounts of experimental data and to plot graphs containing error bars.

Transfer of evidence

A report on an Advanced Higher Unit 2 or Unit 3 prescribed practical activity may be used as evidence to meet the Outcome 3 requirements of this unit.

Candidates, who are repeating a year, may use evidence of an appropriate standard generated in a previous year.

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment Arrangements* (SQA, 2001).

National Unit Specification: general information

UNIT Chemical Investigation (Advanced Higher)

NUMBER D075 13

COURSE Chemistry (Advanced Higher)

SUMMARY

The unit seeks to develop opportunities for the candidate to further develop investigative skills through the completion of an investigation. It also provides the opportunity for self-motivation and organisation.

OUTCOMES

1 Develop a plan for an investigation.
2 Collect and analyse information obtained from the investigation.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates will normally be expected to have attained:

- Higher Chemistry or its component units
- or equivalent.

CREDIT VALUE

0.5 credits at Advanced Higher.

Administrative Information

Superclass: RD

Publication date: June 2002

Source: Scottish Qualifications Authority

Version: 03

National Unit Specification: general information (cont)

UNIT Chemical Investigation (Advanced Higher)

CORE SKILLS

Core skills for this qualification remain subject to confirmation and details will be available at a later date.

Additional information about core skills is published in the *Catalogue of Core Skills in National Qualifications* (SQA, 2001)

National Unit Specification: statement of standards

UNIT Chemical Investigation (Advanced Higher)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

NOTE ON RANGE FOR THE UNIT

The chemistry associated with the investigation must be at a standard commensurate with Advanced Higher Chemistry level.

OUTCOME 1

Develop a plan for an investigation.

Performance criteria

(a) A record is maintained in a regular manner.
(b) The aims of the investigation are clearly stated.
(c) Experimental procedures and apparatus are appropriate for the investigation.

Evidence requirements

A completed record giving brief summaries to indicate the planning stage. Ideas rejected and important contributions made by the teacher/lecturer or other individuals should be included.

OUTCOME 2

Collect and analyse information obtained from the investigation.

Performance criteria

(a) The collection of the experimental information is carried out with due accuracy.
(b) Relevant measurements and observations are recorded in an appropriate format.
(c) Recorded experimental information is analysed and presented in an appropriate format.

Evidence requirements

A record of the collection and analysis of the information, both of which must be the individual work of the candidate.

National Unit Specification: support notes

UNIT Chemical Investigation (Advanced Higher)

This part of the unit specification is offered as guidance. The support notes are not mandatory.

While the time allocated to this unit is at the discretion of the centre, the notional design length is 20 hours.

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

Candidates can select any suitable topic for investigation provided the chemistry is at an appropriate level of demand. The topic chosen may be outwith the chemistry covered in the other units of the Advanced Higher Chemistry course. A list of suitable topics will be published but candidates will not be restricted to this list.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

The candidate should be allowed to consider a variety of approaches. Independent organisation of both time and resources should be encouraged. Some suitable approaches are detailed in the course specification.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Outcome 1

Candidates should provide a completed record with:

- regular entries during the investigation
- notes/comments on ideas rejected
- notes/comments on planning and design
- contributions made by other individuals
- notes/comments on selection of method used
- notes on risk assessment.

OUTCOME 2

Related to PC (a), the teacher/lecturer checks by observation that the collection of information:

- is the individual work of the candidate
- has been obtained with due accuracy.

Candidates should provide a record of experimental information obtained during the investigation which relates to the performance criteria detailed below:

PC (b) Readings or observations (raw data) should be recorded in a tabular format with:

- correct headings
- appropriate units
- readings/observations entered correctly.

National Unit Specification: support notes (cont)

UNIT Chemical Investigation (Advanced Higher)

PC (c) Experimental information should be analysed and presented using the following as appropriate:

- sources of error
- estimate of error
- calculations
- factors affecting yield
- reference data, eg for identification of products
- tabular presentation of derived and final results
- graphical presentation of derived and final results.

The bullet points under each performance criterion give an indication of what should be addressed to achieve a pass. The relevance of the bullet points will vary according to the investigation. These bullet points are intended as helpful guidance. The decision of pass or fail is to be made by the professional judgement of the presenting centre (subject to moderation) against the performance criteria. It is appropriate to give limited support to candidates to meet the performance criteria. The extent of the support should be briefly documented by the candidate in the day book.

Candidates may use Excel or any other suitable data analysis software when tackling Outcome 2. However, candidates must not be given a spreadsheet with pre-prepared column headings or formula since they are being assessed on their ability to enter quantities and units into a table and to make decisions about appropriate scales and labels on graph axes. Excel may also be used to analyse large amounts of experimental data and to plot graphs containing error bars.

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment Arrangements* (SQA, 2001).