Advanced Higher Course Assessment Specification

Advanced Higher Chemistry Course Assessment Specification (C713 77)

Valid from August 2015

This edition: April 2016, version 2.2

Please refer to the note of changes at the end of this Course Assessment Specification for details of changes from previous version (where applicable).

Course outline

Course title:	Advanced Higher Chemistry
SCQF level:	7 (32 SCQF credit points)
Course code:	C713 77
Course assessment code:	X713 77

The purpose of the Course Assessment Specification is to ensure consistent and transparent assessment year on year. It describes the structure of the Course assessment and the mandatory skills, knowledge and understanding that will be assessed.

Course assessment structure

Component 1 — question paper	100 marks
Component 2 — project	30 marks
Total marks	**130 marks**

This Course includes eight SCQF credit points to allow additional time for preparation for Course assessment. The Course assessment covers the added value of the Course.

Equality and inclusion

This Course Assessment Specification has been designed to ensure that there are no unnecessary barriers to assessment. Assessments have been designed to promote equal opportunities while maintaining the integrity of the qualification.

For guidance on assessment arrangements for disabled learners and/or those with additional support needs, please follow the link to the Assessment Arrangements web page: www.sqa.org.uk/sqa/14977.html.

Guidance on inclusive approaches to delivery and assessment of this Course is provided in the *Course Support Notes*.

Assessment

To gain the award of the Course, the learner must pass all of the Units as well as the Course assessment. Course assessment will provide the basis for grading attainment in the Course award.

Course assessment

SQA will produce and give instructions for the production and conduct of Course assessments based on the information provided in this document.

Added value

The purpose of the Course assessment is to assess added value of the Course as well as confirming attainment in the Course and providing a grade. The added value for the Course will address the key purposes and aims of the Course, as defined in the Course Rationale. It will do this by addressing one or more of breadth, challenge or application.

In this Course assessment, added value will focus on the following:

- breadth — drawing on knowledge and skills from across the Course
- challenge — requiring greater depth or extension of knowledge and/or skills
- application — requiring application of knowledge and/or skills in practical or theoretical contexts as appropriate

This added value consists of:

- a question paper, which requires learners to demonstrate aspects of challenge and application; learners will apply breadth and depth of skills, knowledge and understanding from across the Course to answer questions in chemistry
- a project, which requires learners to demonstrate aspects of challenge and application; learners will apply skills of scientific inquiry, using related knowledge, to carry out a meaningful and appropriately challenging task in chemistry and communicate findings

Grading

Course assessment will provide the basis for grading attainment in the Course award.

The Course assessment is graded A–D. The grade is determined on the basis of the total mark for all Course assessments together.

A learner's overall grade will be determined by their performance across the Course assessment.

Grade description for C
For the award of Grade C, learners will have demonstrated successful performance in all of the Units of the Course. In the Course assessment, learners will typically have demonstrated successful performance in relation to the mandatory skills, knowledge and understanding for the Course, by:

- retaining knowledge and scientific skills over an extended period of time
- integrating knowledge and understanding and scientific skills acquired through the study of the component Units
- applying knowledge and understanding and scientific skills set in contexts similar to those associated with the component Units
- applying knowledge and understanding, and scientific skills, to solve problems
- selecting, analysing and presenting relevant information collected through experimental, observational or research work
- reporting in a scientific manner which communicates the chemistry relating to the Course

Grade description for A
For the award of Grade A, learners will have demonstrated successful performance in all of the Units of the Course. In the Course assessment, learners will typically have demonstrated a high level of performance in relation to the mandatory skills, knowledge and understanding for the Course.

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

- retaining an extensive range of knowledge and scientific skills over an extended period of time
- integrating an extensive range of knowledge and understanding and scientific skills acquired across the component Units
- applying knowledge and understanding, and scientific skills, in less familiar and/or more complex contexts than in the component Units
- integrating knowledge and understanding and scientific skills to solve problems in less familiar and more complex contexts
- showing proficiency in selecting, analysing and presenting relevant information collected through experimental, observational or research work
- showing proficiency in reporting in a scientific manner that communicates the chemistry relating to the Course by analysing and interpreting information, in a critical and scientific manner, and demonstrating depth of knowledge and understanding

Credit
To take account of the extended range of learning and teaching approaches, remediation, consolidation of learning and integration needed for preparation for external assessment, six SCQF credit points are available in Courses at National 5 and Higher, and eight SCQF credit points in Courses at Advanced Higher. These points will be awarded when a Grade D or better is achieved.

Structure and coverage of the Course assessment

The Course assessment will consist of two Components: a question paper and a project.

Component 1 — question paper
The purpose of this question paper is to assess breadth and depth of knowledge and understanding from across the Units.

The question paper will assess scientific inquiry skills and analytical thinking skills.

The question paper will give learners an opportunity to demonstrate the following skills, knowledge and understanding by:

- demonstrating knowledge and understanding of chemistry by making statements, describing information, providing explanations and integrating knowledge
- applying knowledge of chemistry to new situations, interpreting information and solving problems
- planning or designing experiments/investigations including safety measures to test given hypotheses or to illustrate particular effects
- selecting information from a variety of sources and presenting information appropriately in a variety of forms
- processing information/data (using calculations and units, where appropriate)
- making predictions and generalisations based on evidence/information
- drawing valid conclusions and giving explanations supported by evidence/justification
- identifying sources of uncertainty and suggesting improvements to experiments

The mandatory skills and knowledge are specified in the 'Further mandatory information on Course coverage' section at the end of this Course Assessment Specification.

The question paper will have 100 marks.
The question paper will have two Sections.

Section 1 will contain objective questions and will have 30 marks.

Section 2 will contain restricted and extended response questions and will have 70 marks.

Marks will be distributed approximately proportionately across the Units.

The majority of the marks will be awarded for applying knowledge and understanding. The other marks will be awarded for applying scientific inquiry and problem solving skills.

A data booklet containing relevant data and formulae will be provided.

Component 2 — project
The purpose of the project is to allow the learner to carry out an in-depth investigation of a chemistry topic and produce a project–report.

Prior to starting this assessment learners should have started a chemistry investigation as part of the *Researching Chemistry* Unit. In this Unit, learners are required to plan and carry out a chemistry investigation. Learners should keep a record of their work as this may form the basis of their project–report. This record should include details of their research, experiments and recorded data. Typically, this may include a series of experiments with at least two different techniques.

The topic will be chosen by the learner, who will individually investigate/research the underlying chemistry. This is an open-ended task which may involve a significant part of the work being carried out without close supervision. The learner will extend and apply the skills of independent/autonomous working. This includes making independent and rational decisions based on evidence and interpretation of scientific information, and the analysis and evaluation of their results. This will further develop and enhance their scientific literacy.

The project will assess the application of skills of scientific inquiry and related chemistry knowledge and understanding.

The project will give learners an opportunity to demonstrate the following skills, knowledge and understanding by:

- extending and applying knowledge of chemistry to new situations, interpreting and analysing information to solve complex problems
- planning and designing chemical experiments/investigations, using reference materials and including risk assessments, to test a hypothesis or to illustrate particular effects
- recording systematic detailed observations and collecting data
- selecting information from a variety of sources and presenting detailed information appropriately, in a variety of forms
- processing and analysing chemical information/data (using calculations, significant figures and units, where appropriate)
- making reasoned predictions and generalisations from a range of evidence/information
- drawing valid conclusions and giving explanations supported by evidence/justification
- critically evaluating experimental procedures by identifying sources of uncertainty, suggesting and implementing improvements
- drawing on knowledge and understanding of chemistry to make accurate statements, describe complex information, provide detailed explanations and integrate knowledge
- communicating chemical findings/information fully and effectively
- analysing and evaluating scientific publications and media reports

The project will have 30 marks.

The majority of the marks will be awarded for applying scientific inquiry skills. The other marks will be awarded for applying related knowledge and understanding.

The learner will submit their project–report as evidence. The project–report will be externally assessed using the following assessment categories:

Category	Marks allocation
Abstract	1
Introduction	4
Procedures	9
Results	6
Discussion (conclusion(s) and evaluation)	8
Presentation	2
Total	30

Setting, conducting and marking of assessment

Question paper

This question paper will be set and marked by SQA, and conducted in centres under conditions specified for external examinations by SQA. Learners will complete this in 2 hours and 30 minutes.

Controlled assessment — project

This project is:

- set by centres within SQA guidelines
- conducted under some supervision and control

and

- evidence will be submitted to SQA for external marking.

All marking will be quality assured by SQA.

The production of evidence for the project will be conducted:

- in time to meet a submission date set by SQA
- independently by the learner

Further mandatory information on Course coverage

The following gives details of mandatory skills, knowledge and understanding for the Advanced Higher Chemistry Course. Course assessment will involve sampling the skills, knowledge and understanding. This list of skills, knowledge and understanding also provides the basis for the assessment of Units of the Course.

The following gives details of the skills:

- extending and applying knowledge of chemistry to new situations, interpreting and analysing information to solve complex problems
- planning and designing chemical experiments/investigations, using reference materials and including risk assessments, to test a hypothesis or to illustrate particular effects
- carrying out complex experiments in chemistry safely, recording systematic detailed observations and collecting data
- selecting information from a variety of sources and presenting detailed information appropriately in a variety of forms
- processing and analysing chemical information/data (using calculations, significant figures and units, where appropriate)
- making reasoned predictions and generalisations from a range of evidence/information
- drawing valid conclusions and giving explanations supported by evidence/justification
- critically evaluating experimental procedures by identifying sources of uncertainty, suggesting and implementing improvements
- drawing on knowledge and understanding of chemistry to make accurate statements, describe complex information, provide detailed explanations and integrate knowledge
- communicating chemical findings/information fully and effectively
- analysing and evaluating scientific publications and media reports

These skills will be assessed, across the Course, in the context of the mandatory knowledge.

The following table provides further detail of the mandatory knowledge for the Advanced Higher Chemistry Course.

Inorganic and Physical Chemistry

Electromagnetic radiation and atomic spectra

Electromagnetic waves
The relationship $c=f\lambda$
Dual nature of electromagnetic radiation — waves and particles
The relationships $E=hf$ and $E=Lhf$
Atomic emission
Evaluation of evidence for energy levels in atoms of elements
Atomic emission spectroscopy and atomic absorption spectroscopy and how they are used to identify and quantify the elements present in a sample

Atomic orbitals, electronic configurations and the Periodic Table

The four quantum numbers used to describe any electron within an atom.
The shapes of s, p and d orbitals
Electron configuration including:

- aufbau principle
- Hund's rule
- Pauli exclusion principle

The Periodic Table is subdivided corresponding to electron configurations.
Ionisation energies as evidence for electron configurations.
The relative values of first, second and subsequent ionisation energies can be evaluated in terms of the stabilities of different subshell electron configurations.
Shapes of molecules and polyatomic ions.
Apply VSEPR rules to determine shapes of molecules and polyatomic ions.

Transition metals

Electronic configuration of transition metal atoms and ions and the anomalies of the model explained.
Oxidation states of transition metals.
Oxidation numbers of transition metal ions.
Using changes in oxidation number of transition metal ions to determine whether oxidation or reduction has occurred.
Dative covalent bonding of ligands in transition metal complexes.
Classification of ligands.
Co-ordination number.
Naming complex ions according to IUPAC rules.
Explanation of colour in transition metal complexes.
UV and visible absorption of transition metal complexes.
Catalysis by transition metals.
Transition metals and their compounds can act as catalysts.

Chemical equilibrium

Equilibrium expressions, factors affecting equilibria and calculation of the composition of the equilibrium mixtures.
Ionic product of water and calculations of pH.
$pH = -\log_{10}[H^+]$
$Kw = [H^+][OH^-]$
Bronsted-Lowry acids/bases definitions.
pH of salt solutions.
Equilibria of the salt solutions.
Strong and weak acids and bases.
Properties of strong and weak acids and bases.

The acid dissociation constant, Ka, $K\text{a} = \frac{[H^+][A^-]}{[HA]}$

pKa = $-\log_{10} K\text{a}$

Calculation of pH for a weak acids pH = ½ pKa - ½ $\log_{10}$c

Buffer solutions.

Composition of a buffer, how buffers work and calculation of the pH of buffers.

pH = pKa – $\log_{10}$ [acid]/[salt]

Indicators.

Weak acid indicators.

K_{in} , $K_{In} = \frac{[H_3O^+]\,[In^-]}{[HIn]}$

Selection of an appropriate indicator for a particular reaction based on titration curves.

Colour change of weak acid indicators.

Reaction feasibility

Standard enthalpy of formation, definitions and relevant calculations.

$\Delta H^o = \Sigma \Delta H^o_f$ (products) - $\Sigma \Delta H^o_f$ (reactants).

Entropy and prediction of the effect on entropy of changing the temperature or state

Second and Third Laws of Thermodynamics.

Calculations in changes in standard entropy.

$\Delta S^o = \Sigma \Delta S^o$ (products) - $\Sigma \Delta S^o$ (reactants).

The concept of free energy $\Delta G = \Delta H - T\Delta S$

Calculation of standard free energy change for a reaction.

$\Delta G^o = \Sigma\, \Delta G^o$ (products) - $\Sigma\, \Delta G^o$ (reactants).

Applications of the concept of free energy.

Prediction of the feasibility of a chemical reaction under standard and non-standard conditions $\Delta G^o = \Delta H^o - T\Delta S^o$

Kinetics

Determination of the order of a reaction (0, 1, 2, 3) from experimental data and rate equations.

Calculation of rate constants and units of k.

rate = k[A]

Determine the rate equation from experimental data.

Reaction mechanisms.

The rate determining step in a reaction.

From the rate equation predict the rate determining step and possible mechanism.

Organic Chemistry and Instrumental Analysis

Molecular orbitals

Formation of bonding molecular orbitals.

Hybridisation sp^3, sp^2, sp hybrid orbitals and their role in the formation of sigma and pi bonds.

The bonding continuum.

The symmetry and position of bonding orbitals between atoms determines types of bonding.

Ionic, polar and non-polar covalent bonding.

Absorption of visible light by organic molecules.

An explanation of why organic compounds are colourless or coloured with reference to molecular orbital theory or conjugated systems.

Chromophores.

Describe a chromophore and explain its role in the colour exhibited by the compound.

Molecular structure
Conversion between molecular, structural and skeletal formulae with no more than 10 carbon atoms in their longest chain.

Stereo chemistry
Stereoisomerism.
Geometric isomerism.
cis and *trans.*
Physical and chemical properties of geometric isomers.
Optical isomerism.
Non-superimposable mirror image, chiral/enantiomers.
Racemic mixture and effect on polarised light.
Physical and chemical properties of optical isomers.

Synthesis
From given equations identify: substitution, addition, elimination, condensation, hydrolysis, oxidation and reduction reactions.
Devise synthetic routes, with no more than three steps, from a given reactant to a final product.
Deduce possible reactions from molecular structures.
Bond fission – homolytic and heterolytic fission.
Electrophiles and nucleophiles.
Reactions involving heterolytic bond fission.
Nucleophiles or electrophiles as attacking groups.
Curly arrow notation – use of double-headed, single-headed and curly arrows to show electron movement.
The curly arrow shows source and destination of the electron(s).
Haloalkanes
Classification of monohaloalkanes as primary, secondary or tertiary.
Monohaloalkanes undergo nucleophilic substitution reactions:

- alkalis to form alcohols
- alcoholic alkoxides to form ethers
- ethanolic cyanide to form nitriles which can be hydrolysed to carboxylic acids

Monohaloalkanes can also undergo elimination reactions to form alkenes.
The reaction mechanism for S_N1 and S_N2 reactions.
S_N1 and S_N2 reactions using curly arrows and mechanisms with particular attention given to the transition state/intermediate.
Alcohols
The preparation properties and reactions of alcohols.
Preparation from alkenes, haloalkanes and reduction of carbonyl compounds using lithium aluminium hydride.
Physical properties related to bonding.
Dehydration, reaction with metals
Reactions with carboxylic acids and acid chlorides.
Ethers
Naming and general structure.
Boiling point related to bonding.
Preparation using haloalkanes with alkoxides.
Chemical and physical properties of ethers linked to molecular size and uses.
Alkenes
Preparation:

- dehydration of alcohols
- base-induced elimination of hydrogen halides from monohaloalkanes

Electrophilic addition reactions:

- catalytic addition of hydrogen to form alkanes
- mechanism for addition of halogens to form dihaloalkanes
- mechanism for addition of hydrogen halides according to Markovnikov's rule, to form monohaloalkanes
- mechanism for acid-catalysed addition of water according to Markovnikov's rule, to form alcohols

Carboxylic acids

Preparation by:

- oxidising primary alcohols and aldehydes
- hydrolysing nitriles, esters, amides

Reactions:

- formation of salts by reactions with metals or bases
- condensation reactions with alcohols to form esters in the presence of an acid catalyst
- reaction with amino groups to form amide links
- reduction with lithium aluminium hydride to form primary alcohols

Amine

Amine classification as primary, secondary or tertiary.
Physical properties related to structure.
Amines as weak bases and their use in salt formation.

Aromatic hydrocarbons

Aromatic hydrocarbons and reactions of benzene.
Structure, bonding and stability of the benzene ring.
Substitution reactions of benzene (phenyl); alkylation, nitration, sulfonation and halogenation as examples of electrophilic substitution in benzene and other aromatic compounds.

Experimental determination of structure

Elemental microanalysis

Determination of the masses of C, H, O, S and N in a sample of an organic compound in order to determine its empirical formula.

Mass spectrometry

Interpretation of fragmentation data to gain structural information.

Infra-red spectroscopy

Interpretation of spectral data to gain structural information.

^{1}H NMR

Interpretation of ^{1}H NMR spectra.
Understanding how a proton NMR spectrum is produced.
Interpretation of spectral data to gain structural information.
Draw and analyse low resolution proton NMR spectra and analyse high resolution proton NMR spectra.

Pharmaceutical chemistry

Effect of drugs on the body.
Classification of drugs as agonists or as antagonists.
How drugs work.
Identify the types of interaction between drug functional groups and receptor sites.
Recognise the active structural fragments in drug molecules which confer pharmacological activity.

% solution by mass, % solution by volume and ppm, calculations.

Researching Chemistry

Throughout each of the key areas the following must be considered:

- precision
- accuracy
- uncertainties
- units

Gravimetric analysis

Analytical determination of the mass of an element or compound in a substance by chemically changing the substance.

Understanding of key techniques including 'weighing by difference' and 'heating to constant mass'.

Volumetric analysis

Appreciation of the characteristics of substances that can be used as a primary standard.

Good practice in preparation of a standard solution and their use in determination of a solution's unknown concentration.

Understanding the role of a control in experiments to validate techniques.

Understanding the use of complexometric titration in quantitative analysis of solutions containing a metal ion.

Understanding of back titrations and associated calculations.

Practical skills and techniques

Preparation of standard solutions using accurate dilution technique.

Formation and use of calibration curves, using colorimetry to determine unknown concentration using solutions of appropriate concentration.

Knowledge of the appropriate use of distillation, heating under reflux, vacuum filtration, recrystallisation and a separating funnel in the preparation and purification of substances.

Knowledge of the appropriate uses of thin-layer chromatography, melting point and mixed melting point determination in evaluating the purity of an experimental product.

Calculation of R_f values from relevant data.

Stoichiometric calculations

Calculations from balanced equations, including multi-step reactions, reactant excess, and empirical formulae from given data.

Calculations and explanations comparing theoretical and actual yield.

Administrative information

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History of changes

Course details	Version	Description of change	Authorised by	Date
	2.0	Significant change to mark allocation of question paper. Significant changes to structure and coverage of the Course assessment. Minor changes to skills and mandatory knowledge.	Qualifications Development Manager	April 2015
	2.1	Formatting errors within equations corrected.	Qualifications Manager	September 2015
	2.2	Minor amendments to wording made throughout to increase clarity.	Qualifications Manager	April 2016