

GCE

in

Chemistry

S P E C I F I C A T I O N

For first teaching from Autumn 2004

For first AS examination in 2005

For first A2 examination in 2006

FOREWORD

This booklet contains CCEA's Advanced Subsidiary (AS) and Advanced GCE Chemistry specification for teaching from September 2004.

The AS is the first part of the full Advanced GCE course. It will be assessed at a standard appropriate for candidates who have completed half of the full Advanced GCE course. The full Advanced GCE comprises the AS and the second half of the Advanced GCE course referred to as A2. However, the AS can be taken as a 'stand-alone' qualification without progression to A2. The A2 will be assessed at a standard appropriate for candidates who have completed a full Advanced GCE course and will include an element of synoptic assessment. The Advanced GCE award will be based on the aggregation of the marks from the AS (50%) and the A2 (50%).

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KEY FEATURES

- free-standing AS course;
- experimental and investigative skills through externally-examined units and coursework;
- opportunities for IT demonstrations and simulations;
- opportunities for developing evidence for assessment of Key Skills.

SUMMARY OF EXAMINATION INFORMATION

Teaching/ learning module	Assessment Unit	Nature of Assessment	Test time	Percentage weighting	Examination availability
AS 1	1	External/ written test	1 hr 30 min	17.5	Winter, Summer
AS 2	2	External/ written test	1 hr 30 min	17.5	Winter, Summer
AS 3	3	External/ practical examination	2 hr 30 min	15	Summer
A2 1	4	External/ written test	1 hr 15 min	15	Summer
A2 2	5	External/ written test	1 hr 15 min	15	Summer
A2 3	6A	External/ written test	1 hr 30 min	13.3	Summer
A2 3	6B	Internal/ practical coursework		6.7	Summer

1 INTRODUCTION

1.1 RATIONALE

This specification is designed to promote continuity, coherence and progression within the study of Chemistry. The AS builds on (*but does not depend upon*) the knowledge, understanding and skills developed within GCSE Science: Chemistry or GCSE Science: Double Award. The Advanced GCE specification incorporates the AS. The A2 section of the Advanced GCE builds upon the foundations of knowledge, understanding and skills developed within the AS and provides the basis for further study of Chemistry and related subjects.

This specification adheres to the 1999 Subject Criteria for AS and Advanced GCE Chemistry and has been designed to conform with the GCE Advanced Subsidiary and Advanced Level Examinations Qualification-Specific Criteria and Common Criteria established jointly by the regulatory authorities in England, Wales and Northern Ireland and published by the Qualifications and Curriculum Authority (QCA).

Chemistry is the study of elements and the compounds they form. The spiritual, moral ethical, social and cultural issues which arise from this study will provide the opportunity for students to discuss and analyse the contribution of chemistry to society. This will involve a critical appraisal of the use of finite resources, the way in which they are used, and development of a global responsibility for ethical use of advances in chemistry. The Key Skill of Communication can be used to explore these issues and examples can be found in the Appendix.

This specification contributes to environmental education by indicating ways in which Chemistry impinges on our environment.

Awareness of environmental and health and safety considerations can be met in:

- 2.2 Hydrocarbons
- 2.6 Alcohols
- 2.7 Equilibrium
- 2.8 Kinetics
- 3.11 Oxy-acids
- 4.2 Transition metals

European developments in this regard can be met through questions using stimulus material to exemplify this context.

This specification has been designed to be as free as possible from ethnic, gender, religious, political or other forms of bias.

1.2 AIMS

AS And A level specifications in chemistry should encourage students to:

- (a) develop essential knowledge and understanding of the concepts of chemistry, and the skills needed for the use of these in new and changing situations;
- (b) develop an understanding of the link between theory and experiment;
- (c) be aware of how advances in information technology and instrumentation are used in chemistry;

- (d) appreciate the contributions of chemistry to society and the responsible use of scientific knowledge and evidence;
- (e) sustain and develop their enjoyment of, and interest in, chemistry.

1.3 ASSESSMENT OBJECTIVES

The assessment objectives provide an indication of the skills and abilities which the assessment units are designed to assess, together with the knowledge and understanding specified in the subject content. It is not always possible to make a clear distinction between these different elements in constructing examination questions and therefore a particular question may therefore test more than one assessment objective.

Certain of the assessment objectives are common to the AS and the A Level. These are listed below:

AO1 Knowledge with understanding

Candidates should be able to:

- (a) recognise, recall and show understanding of specific chemical facts, terminology, principles, concepts and practical techniques;
- (b) draw on existing knowledge to show understanding of the responsible use of chemistry in society;
- (c) select, organise and present relevant information clearly and logically, using specialist vocabulary where appropriate.

AO2 Application of knowledge and understanding, analysis and evaluation

Candidates should be able to:

- (a) describe, explain and interpret phenomena and effects in terms of chemical principles and concepts, presenting arguments and ideas clearly and logically, using specialist vocabulary where appropriate;
- (b) interpret and translate, from one form into another, data presented as continuous prose or in tables, diagrams and graphs;
- (c) carry out relevant calculations;
- (d) apply chemical principles and concepts to unfamiliar situations, including those related to the responsible use of chemistry in society;
- (e) assess the validity of chemical information, experiments, inferences and statements.

AO3 Experiment and investigation

Candidates should be able to:

- (a) devise and plan experimental and investigative activities, selecting appropriate techniques;
- (b) demonstrate safe and skilful practical techniques;
- (c) make observations and measurements with appropriate precision and record these methodically;
- (d) interpret, explain, evaluate and communicate the results of their experimental and investigative activities clearly and logically using

chemical knowledge and understanding, and using appropriate specialist vocabulary.

Assessment objective 4 applies only to the A2 part of the A level course.

AO4 Synthesis of knowledge, understanding and skills

Candidates should be able to:

- bring together knowledge, principles and concepts from different areas of chemistry, including experiment and investigation, and apply them in a particular context, expressing ideas clearly and logically and using appropriate specialist vocabulary;
- use chemical skills in contexts which bring together different areas of the subject.

The weighting of the assessment objectives in the AS and A Level is shown in Table 1.

TABLE 1:

	Assessment Objectives	Weighting		
		AS Level	A2 Level	A Level
AO1	Knowledge with understanding	45-55%	15-25%	30-40%
AO2	Application of knowledge and understanding, analysis and evaluation	30-40%	15-25%	22.5-32.55%
AO3	Experiment and investigation	15-20%	10-20%	12.5-20%
AO4	Synthesis of knowledge, understanding and skills	0%	40%	20%

1.4 SPECIFICATION STRUCTURE

The specification adopts a modular structure and candidates are required to study 3 teaching and learning modules for the AS course and 6 modules for the full A Level course. The modules are listed below :

Module 1: General Chemistry

Module 2: Organic, Physical and Inorganic Chemistry

Module 3: Practical Examination

Module 4: Further Organic, Physical and Inorganic Chemistry

Module 5: Analytical, Transition Metals and Further Organic Chemistry

Module 6A: Synoptic Paper

Module 6B: Teacher-assessed coursework

1.5 KEY SKILLS

The key skill of Communication will contribute to the assessment of this specification through the assessment of candidates' quality of written communication as detailed on page 11.

This specification provides opportunities for developing and generating evidence for assessing the following nationally specified key skills at the levels indicated:

- Communication – Level 3
- Application of Number – Level 3
- Information Technology – Level 3
- Working with Others – Level 3
- Improving Your Own Learning and Performance – Level 3
- Problem Solving – Level 3

The opportunities provided are referenced to the relevant key skills specifications and exemplified in Appendix 1 on page 35.

1.6 OVERLAP WITH OTHER QUALIFICATIONS

There are small amounts of overlap between this specification and GCE specifications in Biology, Physics and Advanced GNVQs in Science (full and Single Award compulsory units).

The overlap is insufficient to restrict the combination of any of these subjects with GCE Chemistry.

1.7 PROHIBITED COMBINATIONS

In any one series of examinations a candidate may not take examinations on this specification together with examinations on another specification of the same title.

Every specification is assigned to a national classification code indicating the subject area to which it belongs.

Centres should be aware that candidates who enter for more than one GCE qualification with the same classification code, will have only one grade (the highest) counted for the purpose of the School and College Performance tables.

The classification code for this specification is 1110.

2 SCHEME OF ASSESSMENT

2.1 THE RELATIONSHIP BETWEEN ASSESSMENT UNITS AND ASSESSMENT OBJECTIVES

The relationship between the assessment units and the assessment objectives is set out in Tables 2 and 3:

TABLE 2: AS ASSESSMENT WEIGHTINGS

Assessment Unit	Nature of Assessment	Assessment Objectives				Assessment Unit Weighting %
		AO1 %	AO2 %	AO3 %	AO4 %	
1	External	21.3	13.7	0	0	35
2	External	21.3	13.7	0	0	35
3	External	5	5	20	0	30
	Totals	47.6	32.4	20	0	100%

TABLE 3: A LEVEL ASSESSMENT WEIGHTINGS

Assessment Unit	Nature of Assessment	Assessment Objectives				Assessment Unit Weighting %
		AO1 %	AO2 %	AO3 %	AO4 %	
1	External	10.7	6.8	0	0	17.5
2	External	10.7	6.8	0	0	17.5
3	External	2.5	2.5	10	0	15
4	External	5	5	0	5	15
5	External	5	5	0	5	15
6A	External	0	0	3.3	10	13.3
6B	Internal	0	0	6.7	0	6.7
	Totals	35	25	20	20	100%

2.2 NATURE OF ASSESSMENT UNITS

The assessment units which make up the AS and full A Level awards are described below:

Assessment Unit AS1

Assessing Module 1 (AS) A written paper lasting 1 hour 30 mins consisting of Section A which contains 10 multiple choice questions (20 marks) and Section B which contains a number of structured questions (80 marks).

Assessment Unit AS2

Assessing Module 2 (AS) A written paper lasting 1 hour 30 mins consisting of Section A which contains 10 multiple choice questions (20 marks) and Section B which contains a number of structured questions (80 marks).

Assessment Unit AS3

Assessing Module 3 (AS) A practical examination (2 hours 30 mins) consisting of a planning exercise (20 marks) a structured question on practical work (20 marks), two practical exercises (25 marks each) involving a Titration or an exercise involving titrimetric techniques and an Observation/Deduction exercise. Candidates will have access to their own notes, textbooks and other resources.

Assessment Unit A2 1

Assessing Module 4 A written paper lasting 1 hour 15 mins consisting of Section A which consists of 10 multiple choice questions (20 marks) and Section B which has a number of structured questions (70 marks). Approximately 30 marks will be for synoptic assessment.

Assessment Unit A2 2

Assessing Module 5 A written paper lasting 1 hour 15 mins consisting of Section A which consists of 10 multiple choice questions (20 marks) and Section B which has a number of structured questions (70 marks). Approximately 30 marks will be for synoptic assessment.

Assessment Unit A2 3A

Assessing Module 6A A synoptic written paper lasting 1 hour 30 mins with a number of structured questions (60 marks) assessing the content of modules 4 and 5; and a Planning exercise (20 marks).

Assessment Unit A2 3B

Assessing Module 6B Teacher – assessed coursework (40 marks) covering the skill areas of:

- 1 Manipulation, measuring and recording;
- 2 Observing and recording;
- 3 Concluding and communication (quantitative);
- 4 Concluding and communication (qualitative).

2.3 THE SEQUENCE, TIMING AND RE-SITTING OF ASSESSMENT UNITS

Assessment units will normally be taken in the following sequence:

Module 1, 2, 3, followed by Modules 4, 5, 6A and B.

Candidates may sit the following assessment units in the winter examination sessions: Modules 1 and 2 and 4.

Modules 3, 5 and 6A may only be taken in the summer examination session.

Students will be able to re-take units more than once. When an entry is made for certification, the better result will count towards the final award. Candidates may, however, retake the whole qualification more than once.

The results of individual assessment units, prior to certification of the qualification will have a shelf-life limited only by the shelf-life of the specification.

2.4 QUALITY OF WRITTEN COMMUNICATION

Assessment will take into account candidates' quality of written communication where they are required to respond in continuous prose. Quality of written communication is incorporated within the assessment objectives of the syllabus and refers to candidates' ability to:

- select and use a form and style of writing appropriate to purpose and to complex subject matter;
- organise relevant material clearly and coherently using specialist vocabulary where appropriate;
- ensure writing is legible, with accurate use of spelling, grammar and punctuation in order to make meaning clear.

Quality of written communication will be assessed within all assessment objectives and assessment units.

2.5 SYNOPTIC ASSESSMENT

The definition of synoptic assessment, in the context of chemistry, is as follows:

Synoptic assessment involves the explicit drawing together of knowledge, understanding and skills learned in different parts of the A Level course. The emphasis of synoptic assessment is on understanding and application of the principles included in the specification.

Synoptic assessment should:

- require candidates to make connections between different areas of chemistry, for example, by applying knowledge and understanding of principles and concepts of chemistry in planning experimental work and in the analysis and evaluation of data
- include opportunities for candidates to use, in contexts which may be new to them, skills and ideas that permeate chemistry, for example, writing chemical equations, quantitative work, relating empirical data to knowledge and understanding.

Synoptic assessment will only take place in the second half, A2, of A Level.

It is not necessary for candidates to wait until the end of their course before being entered for the Synoptic unit.

2.6 RECOMMENDED PRIOR LEARNING

This specification has been written to build upon the knowledge and understanding of Chemistry represented in GCSE Science: Double Award or GCSE Science: Chemistry or GNVQ Intermediate Science. Candidates should normally have achieved a grade C at GCSE or its equivalent in GNVQ Intermediate Science, but this is not a requirement.

2.7 MATHEMATICAL REQUIREMENTS

In order to be able to develop the knowledge, understanding and skills in section 3, students need to have been taught and to have acquired competence in the areas of mathematics set out below. Material given in bold type is for A Level only.

2.7.1 Arithmetic and computation

Students should be able to:

- (a) recognise and use expressions in decimal and standard form;
- (b) use ratios, fractions and percentages;
- (c) make estimates of the results of calculations (without using a calculator);
- (d) **use calculators to find and use x^n , $1/x$, e^x , $\log_{10}x$**

2.7.2 Handling Data

Students should be able to:

- (a) use an appropriate number of significant figures;
- (b) find arithmetic means.

2.7.3 Algebra

Students should be able to:

- (a) change the subject of an equation;
- (b) substitute numerical values into algebraic equations using appropriate units for physical quantities;
- (c) **use logarithms in relation to quantities which range over several orders of magnitude.**

2.7.4 Geometry

Students should be able to:

- (a) appreciate angles and shapes in regular 2-D and 3-D structures;
- (b) visualise and represent 2-D and 3-D forms including two dimensional representations of 3-D objects;
- (c) understand the symmetry of 2-D **and 3-D shapes**.

2.8 AWARDS AND CERTIFICATION

Both the AS and the full A Level will be awarded on a five-grade scale: A, B, C, D and E. Candidates who fail to reach the minimum standard for a grade E will be recorded as U (unclassified) and will not receive an AS or A Level certificate. The results of individual assessment units will be reported. This qualification will

comply with the grading, awarding and certification requirements of the revised GCE Code of Practice for courses starting in September 2000.

2.9 CANDIDATES WITH PARTICULAR REQUIREMENTS

Details of arrangements for candidates with particular assessment requirements are provided in the *Joint Council for General Qualifications GCSE and GCE Regulations and Guidance for Candidates with Special Assessment Needs*.

3 SUBJECT CONTENT

The subject content is organised into 4 teaching and learning modules. The content of these modules is set out below and for each module the major topics to be covered are listed in bold typeface, together with related guidance notes. The notes provide further detail of the content required.

The modules are set out in the normal sequence in which their associated assessment units would be taken. The AS modules are described first followed by the A2 modules which comprise the second half of the full A Level course. The content of each module should be read in conjunction with the relevant aims and assessment objectives set out in Section 1 of this specification.

A copy of the Periodic Table and data will be supplied at each of the examinations. Electronic calculators used must be in accordance with the conditions set out in the Council's Rules and Regulations.

Attention is drawn to the ASE booklet (Chemical Nomenclature, Symbols and Terminology, 1985) and the joint statement by the GCE Examinations Boards on Chemical Nomenclature which may be obtained on application.

In general, SI units will be used and elements and compounds will be named in accordance with the above publications. Familiar trivial names of common organic and inorganic compounds will be given also.

Solid chemicals will be described as white or black or coloured. The term colourless will be applied only to liquid or gaseous substances.

Teachers are advised that approximately half of the total teaching time available for a course leading to the examination in this subject should be spent on experimental work in the laboratory. It is emphasised that this should not be interpreted as applying to each month or week of the course, because for some periods of time a quite different balance will be appropriate, but the advice is offered as being a realistic overall division of time within the subject.

While it is felt that the modules should be taught in the order 1, 2, 4, 5 and that Modules 4 and 5 build on material in Modules 1 and 2, within each module the topics are merely listed and no implication of a teaching sequence for any module is indicated.

Some general aspects apply to all the modules, eg the use of equations and the ability to do calculations are two such cases.

EQUATIONS

The use of balanced equations (full or ionic as suitable) will be expected in all modules.

For organic reactions involving redox the use of [O] and [H] in equations will be acceptable.

CALCULATIONS

Amount of substances, the mole, molar mass, molar volume of gases (24 litre/dm³) at room temperature and pressure, the Avogadro constant and their use in calculations. (Determination of the Avogadro constant not required.)

Calculation of empirical and molecular formulae from analytical data and molar masses.

Calculation of reacting masses and volumes of substances including examples in which some reactants are in excess.

Percentage yields in preparations.

Concentration units are required in titrations eg mole dm^{-3} or mole/litre referred to as molarity (M).

PRACTICAL INORGANIC AND ORGANIC CHEMISTRY

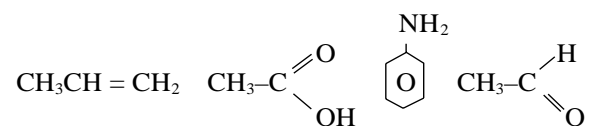
The term 'preparation' is taken to mean that a pure sample of the product should be made on a 5-15g scale. This should involve techniques such as refluxing, treating products to remove solvent and unreacted starting materials, or by-products, recrystallisation, drying, distillation and, where appropriate, melting point and boiling point determination.

Where specific preparations are detailed in the specification, it is expected that the principles of the techniques should be understood and so, for an unfamiliar preparation for which practical details are provided, an explanation involving the techniques would be forthcoming. For any substance listed in the modular content to be prepared, the equation for the reaction and the formula of the product should be known.

It is expected that the study of many of the reactions quoted in the specification will be enhanced by practical investigation, many on a test tube scale (for safety reasons cyanides should not be used), eg investigation of the oxidation of alcohols. Building on good practice from GCSE it is hoped that teachers will adopt an investigative approach to practical activities, where appropriate. This will also aid students in their preparation for any planning exercises required by the specification.

ORGANIC CHEMISTRY

Some organic chemistry appears in each of modules 2, 4 and 5, and in general, emphasis is placed on the classification of compounds by homologous series, functional groups and their interconversions, the existence of isomerism and knowledge of some mechanisms. Only those mechanisms specified will be examined. Where appropriate, the use of curly arrows to show electron rearrangements during elementary steps should be encouraged. Structural formulae (where required) should show clearly the arrangements of atoms and bonds in a functional group, eg:



For the lower members of a homologous series a knowledge is expected of their general physical state under ambient conditions and of trends in boiling points, solubility in or miscibility with water.

INDUSTRIAL CHEMISTRY

The term 'production' is taken to mean the manufacture of the product commercially and would include the application of physico-chemical principles to predicting the most suitable conditions, and practical considerations which are a compromise of thermodynamic and kinetic factors. Consideration should be given to economic, social and environmental aspects.

MODULE 1

1.1 Atomic Structure

Electrons, protons and neutrons as the constituent particles of the atom. Their location in the atom, their relative masses and charges. Atomic number, mass number and isotopes.

Relative atomic mass, relative isotopic mass and relative molecular mass. The carbon-12 standard. The use of the mass spectrometer to obtain accurate atomic masses. (Details of the workings of the mass spectrometer are not required). Deduction of RMM from a molecular ion peak. (Limited to ions with single charges).

A simple introduction to the spectroscopic evidence for discrete energy levels in an isolated hydrogen atom. The equation $E=h\nu$.

The convergence of lines interpreted as convergence of energy levels leading to a value for the ionisation energy. Origin of flame spectra and an experimental study of flame colorations by the chlorides of Li, Na, K, Ca, Sr and Ba.

The evidence, from graphs of first ionisation energies of elements up to krypton and from successive ionisation energies of an element, for the existence of the main energy levels and s, p and d orbitals. Shapes of s and p orbitals.

Electronic structures of atoms and ions up to krypton in terms of main energy levels; the s, p and d notation and electrons-in-boxes notation using the building-up principle. Division of the Periodic Table into s, p and d blocks. spd notation: any question, including those on bonding, asking for an electronic arrangement/configuration/structure should use spd (even if this not specifically stated) and statements, showing an electron arrangement as 2.8.7 will not be credited.

Ionisation energies of atoms broadly related to position in the Periodic Table; explanation in terms of nuclear charge, atomic radius, shielding and stability of filled and half-filled shells.

1.2 Bonding

Metals – a qualitative description of delocalised bonding used to explain typical properties associated with metals; hardness, melting point, electrical conductivity, malleability and ductility.

Ionic bonding restricted to elements in groups I, II, VI and VII, the ions of which have a noble gas structure. Dot and cross diagrams. Characteristic properties of ionic compounds. Sodium chloride as a typical ionic crystal.

Formation of covalent bonds in terms of the sharing of electron pairs between atoms. Dot and cross diagrams. Multiple bonds exemplified by C_2H_4 , N_2 and CO_2 . The octet rule and its limitations, eg $BeCl_2$, BF_3 . The coordinate bond as a special case of the covalent bond eg NH_4^+ . Dot and cross diagrams are required to show only the outermost electrons but, where appropriate, charges should be included.

Characteristic properties of molecular covalent crystals (rhombic sulphur, iodine) and giant covalent structures (diamond, graphite and quartz).

Electronegativity as a guide to polarity of bonds. Numerical values are not required but interpretation of values (in terms of polarity) and general knowledge of the order of electronegativity of simple elements across periods and down groups is expected.

1.3 Shapes of Molecules

Explanation in terms of electron pair repulsion theory for the shapes of molecules containing up to four pairs of electrons around the central atom such as BeCl_2 , BF_3 , CH_4 , NH_3 , H_2O , and CO_2 . (Questions will not be set on hybridisation of orbitals) The departure of the bond angles in NH_3 and H_2O from the predicted tetrahedral, explained in terms of the increasing repulsion between bonding pair-bonding pair, lone pair-bonding pair and lone pair-lone pair electrons.

1.4 Atomic Size

Atomic radii (van der Waals, covalent, ionic or metallic as appropriate). Bond lengths in covalent molecules.

1.5 Intermolecular Forces

Van der Waals forces (viewed as attractions between induced dipoles), permanent dipole attractions and hydrogen bonding (in molecules containing either or both of the O-H and N-H bonds).

Relationships between these attractive forces and the physical properties, such as melting point, boiling point and solubility, of simple molecular substances.

Hydrogen bonding in ice; open structure leading to low density (3D diagram not required).

1.6 Energetics

The concept of an enthalpy change, ΔH , for endothermic and exothermic changes. Simple enthalpy level diagrams. Explanation of enthalpy changes associated with changes of state.

Simple experimental study of enthalpy changes and calculation of standard enthalpy changes from experimental data.

Standard enthalpy changes of reaction, combustion, formation, neutralisation.

Conservation of energy and Hess's Law to calculate enthalpy changes.

Average bond enthalpy of covalent bonds and the use of tables of bond enthalpies to estimate the enthalpy change in simple reactions.

Enthalpy changes associated with the dissolving of ionic compounds in water.

1.7 Redox

Oxidation and reduction in terms of electron transfer. The concept and use of oxidation numbers. The idea that the oxidation number of an element changes in a redox reaction.

Balancing of redox equations from given half equations and for reactions where the reactants and products are specified (omitting spectator ions).

Redox potentials as a guide to the relative oxidising ability of the halogens. (A formal treatment of the hydrogen electrode and cells is not required).

1.8 The Periodic Table

The organisation of elements in the Periodic Table according to their proton numbers and electronic structures. The terms group and period. The trends in the physical properties across the period sodium to argon limited to melting points, electrical conductivity, first ionisation energies and atomic radii.

Group VII (fluorine, chlorine, bromine and iodine)

Practical work restricted to chlorine, bromine and iodine and their compounds.

Trends within the group limited to colour, physical state, melting and boiling points, atomic and ionic radii, first ionisation energies, bond energies of halogen molecules, hydrogen halides and carbon-halogen bonds; electronegativities.

Solubility in water and non-aqueous solvents eg hexane.

Chemical trends: reactivity with hydrogen, sodium and phosphorus.

Reactions of the elements illustrated by use of chlorine gas (or chlorine water), bromine water and aqueous iodine (in potassium iodide) with water, aqueous alkalis, other halides in solution and iron (II) and iron (III) ions as appropriate. Disproportionation.

Thermal stability of hydrogen halides related to bond enthalpies. The relative strength of the acids, HF, HCl, HBr and HI.

Ionic halides. The identification of halide ions in solution by use of silver ions followed by aqueous ammonia. The effect of light on silver halides. Presence of halide ions in sea water. The reaction of solid halides with concentrated sulphuric acid to illustrate the relative reducing ability of halides ions and hydrogen halide. The effects of fluoridation of public water supplies on dental health and an appreciation of the debate between public health policy and practice and the rights of the individual.

1.9 Titrations

The practical aspects of titrations are required in the assessment of practical skills.

Acid-base Titrations

Acid-base titrations involving strong acid/strong base, strong acid/weak base and weak acid/strong base, eg determination of the degree of hydration in a sample of sodium carbonate, analysis of vinegar. The knowledge of suitable indicators for these titrations.

Iodine Titrations

The reaction between iodine and thiosulphate ions using starch as an indicator. The use of this reaction to estimate oxidising agents such as hydrogen peroxide and iodate ions (IO_3^-) by their reactions with excess potassium iodide (equations for I_2 formation will be provided where appropriate).

A knowledge of the techniques of titrations is expected but it would be normal to assume that all apparatus would have been washed with distilled/deionised water. The description should include which reagent is placed in the burette, name of indicator (but no reason for choice of indicator), detection of endpoint and what should be observed, repetition for accuracy. The equation between iodine and thiosulphate ions should be known.

MODULE 2**2.1 Isomerism in Organic Compounds**

Structural isomerism for aliphatic compounds containing up to six carbon atoms, to include branched structures and position of the C=C double bond in alkenes. (Cyclic compounds excluded.)

Stereoisomerism: cis-trans for compounds containing one C=C bond, the energy barrier to rotation in these compounds.

2.2 Hydrocarbons

Petroleum as a source of hydrocarbons by fractional distillation and cracking. A knowledge of how these processes are carried out, including the names and nature of the fractions obtained, is expected. (Reforming to benzene derivatives is not required in this module.) Environmental problems associated with spillage and combustion of hydrocarbons, including global warming and ozone depletion.

2.3 Alkanes

Combustion in a limited and plentiful supply of air. (See section 2.8, catalytic converters).

Reactions with chlorine and bromine limited to monohalogenation (except for methane and chlorine).

Mechanism of the photochemical reaction between methane and chlorine viewed as free radical substitution.

2.4 Alkenes

σ and π bonds used to explain the relative bond strength and relative bond length of C=C compared to C-C, and the difference in reactivity of alkanes and alkenes.

Reactions of Cl₂, Br₂, HCl and HBr with simple alkenes (Markovnikov's rule not required). Mechanism of the reaction between hydrogen bromide and ethene viewed as electrophilic addition.

Catalytic hydrogenation of alkenes using finely divided nickel and application to the hardening of oils (detailed structure of oil molecule not required). See also section 4.9.

Industrial reactions of ethene restricted to a knowledge of reagents and conditions for the production of ethanol and both LD and HD polythene. Chemical inertness of polythene, non-biodegradability leading to the need to develop waste management strategies, the land fill versus incineration debate. Simple physical properties, flexibility and softening temperature related to branching and crystallinity.

2.5 Halogenoalkanes

Preparation of a primary bromoalkane from the corresponding alcohol.

Reactions with aqueous alkali, ammonia and cyanide ions.

Substitution with hydroxide ions. Mechanisms of the reactions of primary and tertiary bromoalkanes with hydroxide ions, viewed as nucleophilic substitution.

Relative strength and reactivity of carbon-halogen bonds. Comparative ease of hydrolysis of 1-chlorobutane, 1-bromobutane and 1-iodobutane related to bond enthalpy and bond polarity.

Elimination of hydrogen halide using hydroxide ions in alcohol.

Preparation of a pure sample of iodoform.

2.6 Alcohols

Physical properties. Reference to the effect of hydrogen bonding on boiling point and miscibility with water. The place of alcohol in society as a recreational drug which can have beneficial and harmful effects. The idea of safe limits of 'units' of alcohol.

Combustion of ethanol and its production from sugar cane and use as an alternative fuel to conserve fossil fuels and to reduce air pollution from oxides of sulphur and carbon.

Oxidation of alcohols by acidified dichromate. Difference between primary, secondary and tertiary alcohols with respect to mild oxidation.

Esterification reactions of simple alcohols with carboxylic acids and with ethanoyl chloride.

Reactions of primary alcohols with sodium, hydrogen bromide, phosphorus pentachloride and thionyl chloride.

The iodoform test to distinguish between alcohols containing $\text{CH}_3\text{CH}(\text{OH})-$ and other alcohols.

2.7 Equilibrium

The dynamic nature of the equilibrium state.

For homogeneous reactions, the qualitative effects of changes of catalyst, temperature, pressure and concentration on the position of equilibrium. Influence of these effects in industrial processes such as the synthesis stage of the Haber-Bosch process and the Contact process, precautions against SO_2 emissions. In these processes candidates would be expected to know the conditions required but if a different process is used then information would be supplied for interpretation.

2.8 Kinetics

Simple collision theory including how the factors affecting rates of reaction may be explained. Definition of a catalyst. Definition of activation energy.

Qualitative explanation of the effects of concentration, temperature and catalysis on rate of reaction in terms of the distribution of molecular kinetic energies and activation energy, where appropriate.

Use of reaction profiles to illustrate the role of catalysts in providing an alternative reaction pathway with a lower activation energy and to explain the difference between thermodynamic stability and kinetic stability.

Examples of homogeneous catalysis involving the formation of an intermediate, and heterogeneous catalysis involving chemisorption.

Enzymes regarded as biological catalysts. It is expected that candidates will be able to state that an enzyme is a protein (although detailed knowledge of proteins is confined to later modules) has an active site and provides a path of lower activation energy. Details of the mechanisms of enzyme catalysis are not expected in this module.

A simple account of the role of catalytic converters in reducing the environmental damage due to vehicle emissions by facilitating the conversion of carbon monoxide to carbon dioxide, of unburnt hydrocarbons to carbon dioxide and water

and of NO_x to nitrogen; catalyst poisoning by lead. (Technical details of the construction of catalytic converters are not required.)

Catalytic effect of chlorine on ozone in the upper atmosphere.

2.9 Group II (magnesium to barium, as indicated)

Trends within the group limited to colour, physical state, melting points, atomic and ionic radii, first ionisation energy.

Where possible, the following should be investigated practically.

Chemical trends, including combustion, reaction with water and dilute acids. Flame colorations produced by the metal ions. Basic nature of oxides. Thermal stability of carbonates and hydroxides related to cation size and lattice energies. Solubility trends of sulphates and hydroxides explained only by enthalpy considerations.

Analytical uses of the ions as exemplified by the use of:
barium ions to test for sulphate and sulphite, magnesium ions to distinguish between hydrogencarbonate and carbonate ions in solution; back titration to determine the purity of a group II metal, oxide or carbonate.

2.10 Identification Tests

Observations and chemistry involved in the ion tests referred to in Modules 1 and 2 and also the following gases – any one chemical test.

H_2 , O_2 , Cl_2 , CO_2 , SO_2 , HCl , NH_3

MODULE 4

4.1 Lattice Energy

Simple treatments (including calculations) of the Born-Haber cycle for the halides of Groups I and II. (Lattice enthalpy will be regarded as the enthalpy of lattice breaking.)

4.2 Kinetics

Experimental study of the rate of a reaction with variation of reactant concentration.

Simple rate equations in the form: $\text{rate} = k[\text{A}]^x[\text{B}]^y$ with indices either zero or integral; the rate constant and order of reaction. (Integrated rate equations are not required.)

Relationship between the rate equation and mechanism. (Limited to the alkaline hydrolysis of primary and tertiary alkyl halides.)

Qualitative effect of temperature on rate constants and its relationship to activation energy. Simple graphical interpretation in terms of molecular kinetic energies.

4.3 Equilibrium (to include principles from Module 2)

The equilibrium law and equilibrium constant for a homogeneous system in terms of concentration (K_c) and of partial pressures (K_p). The value of K_c in relation to the extent of reaction. Calculations involving K_c and K_p at constant temperature. Partial pressure derived from mole fractions and total pressure. (Calculations will not be set which:

- (a) require the solving the quadratic equations using a formula; and
- (b) involve the interconversions of K_c and K_p .)

The qualitative effects of changes of temperature and pressure on the position of equilibrium and on the value of the equilibrium constant.

The dissociation of water and Ionic Product, K_w . The Brønsted-Lowry theory of acid-base reactions occurring in aqueous solution and the use of the concept of equilibrium to describe proton transfer in acid-base equilibria; K_a and pK_a .

Definition of pH. Calculations involving pH and concentration for strong acids and bases involving pH. K_a and concentration of weak acids.

Experimental determination of titration curves. Use of titration curves in choice of an indicator.

The meaning of the term buffer solution and qualitative explanation of its mode of action. Calculation of pH of a buffer made from a weak monobasic acid and sodium hydroxide.

Buffers in biological systems – a system and its constituent buffer is required, eg blood containing the buffer, carbonic acid/hydrogencarbonate ion, having a pH of 7.4. The importance of the buffer is related to the enzyme activity which is pH dependent.

Salt hydrolysis – predict as to whether a salt solution would be acidic, alkaline or neutral based on relative strengths of the parent acid and base. Qualitative treatment only.

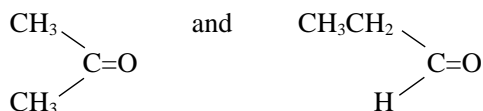
Partition Coefficient K_d . Simple calculations on partition of a solute between two immiscible solvents, including examples involving successive extractions.

4.4 Electrode Potentials

Appreciation that when two dissimilar metals connected by a wire are dipped into a conducting liquid, an electric current will flow in the wire. Use of e.m.f. measurements to construct a reactivity series. Standard electrode potential and the hydrogen electrode. Standard electrode potentials of redox systems with inert electrodes. Use of tables of standard electrode potentials to predict feasibility and direction of reactions, and to calculate e.m.f of a cell. (Calculations involving concentrations or the Nernst equation excluded.)

4.5 Isomerism

Isomerism will incorporate the examples in Module 2. Isomerism between compounds containing different functional groups, eg



Chiral (optical) isomerism in compounds containing a single asymmetric centre.

Candidates are expected to know that a compound prepared in the lab which contains a chiral centre may be a mixture of the optical isomers, but resolution of the isomers is not required, nor is the term 'racemic mixture'.

4.6 Aldehydes and Ketones

Reaction of simple aldehydes and ketones with hydrogen cyanide and 2, 4-dinitrophenylhydrazine. Mechanism of the addition reaction of hydrogen cyanide and propanone viewed as nucleophilic addition. Use of 2, 4-dinitrophenylhydrazine for identification.

Oxidation used to distinguish between aldehydes and ketones, using acidified dichromate, Fehling's solution and Tollen's reagent. (Fehling's solution and Tollen's reagent viewed as Cu^{2+} and Ag^+ respectively.)

Reduction of aldehydes and ketones using lithium (LiAlH₄).

4.7 Carbohydrates

Recognition of the structure of the following carbohydrates: fructose, glucose, maltose, sucrose and starch. Starch consisting of two types of glucose polymer: amylose and amylopectin. Hydrolysis of sucrose by dilute acid and of starch by amylase and dilute acid. Classification of fructose, glucose, maltose, sucrose and starch as monosaccharide, disaccharide or polysaccharide. Comparison of their reactions with dilute sulphuric acid, Fehling's solution and iodine.

4.8 Carboxylic Acids

Formation from primary alcohols, aldehydes and esters. Preparation of an aqueous solution of the acid from the alcohol.

Reference to the effect of hydrogen bonding on boiling point and miscibility with water.

Acidity. Formation of salts using bases such as sodium carbonate, sodium hydroxide and ammonia.

Reaction with alcohols, PCl₅, SOCl₂ and LiAlH₄.

4.9 Esters, Fats and Oils

Preparation of a liquid ester from a carboxylic acid and an alcohol. Formation from alcohols using carboxylic acids and using acyl chlorides. Hydrolysis of esters, catalysed by acid and base.

Structure of fats as esters of propane-1,2,3-triol (glycerol) and fatty acids. Formulae of stearic and oleic acids as examples of saturated and unsaturated fatty acids. The hardening of oils and fats. Consideration of polyunsaturates and polysaturates in a balanced diet. Definition and significance of iodine value, experimental determination of this value for a given fat/oil. Saponification of fats, saponification value. The formation and structure of a simple polyester such as polyethylene terephthalate.

4.10 Periodic Trends

The variation in the character of the elements across the third period, sodium to chlorine, as indicated.

The reactions of the elements with water (where appropriate). Water would include steam where this is required for the element to react.

The reactions of the elements with oxygen and chlorine to form the oxides and chlorides listed below.

Knowledge of the oxides and chlorides limited to formulae, type of bonding, structures (excluding that of phosphorus pentoxide), classification of oxides as acidic, basic or amphoteric and the reaction of the compounds with water (if any).

Na_2O , MgO , Al_2O_3 , SiO_2 , P_4O_{10} , SO_2 , SO_3 , Cl_2O_7 , NaCl , MgCl_2 , Al_2Cl_6 and PCl_5

4.11 Oxy-acids of non-metals (sulphur, nitrogen and phosphorus) and their salts

Commercial aspects

Reactions and chemical principles in the manufacture of sulphuric acid from sulphur, nitric acid from ammonia and phosphoric acid from phosphate rock (wet process). (Details of plant not required.)

The chemical reactions involved in the major uses as listed:

- sulphuric acid in the manufacture of superphosphate;
- nitric acid in the manufacture of ammonium nitrate and polymers (eg nylon);
- phosphoric acid in the manufacture of triplesuperphosphate and diammonium hydrogen phosphate fertilisers;
- advantages and disadvantages of using artificial and natural fertiliser; nitrogen content of natural fertiliser and artificial fertilisers; fish kills and eutrophication.

Laboratory aspects

Reactions of the acids and their salts based on redox properties, stability of oxidation states, acid strength. The variation in strength of acid with the change in oxidation number of the central atom. Detailed knowledge required only for named acids.

Nitrous acid and nitrites: reaction with iron (II), iodide, manganate (VII), bromine water and aluminum (in alkali).

Nitric acid and nitrates: reaction of concentrated acid with iron (II), iodide, copper metal and aluminum (in alkali).

Phosphoric acid: reaction of concentrated acid with iodide (contrast to sulphuric acid); salts with silver and iron (III) ions, and their solubility in dilute nitric acid and ammonia, salt hydrolysis.

Sulphurous acid, sulphite and sulphur dioxide: reactions with manganate (VII), iron (III), halogens and barium ions.

Sulphuric acid and sulphates: reaction of concentrated acid with copper metal, halide ions (see Module 1), sulphates with barium ions.

Thiosulphates: reactions with halogens and silver ions. Uses of these reactions in antichlors and in photography.

MODULE 5**5.1 Analytical Techniques****Mass Spectrometry**

Mass spectra of organic molecules (base peak, molecular ion peak, M+1 peak, fragmentation patterns). Identification of the major fragment ions in a given mass spectrum and of a molecule from its mass spectrum. (Rearrangements will be excluded)

Use of mass spectrometry to determine mechanisms through isotopic labelling.

Nuclear Magnetic Resonance Spectroscopy

Simple outline of the principles of nuclear magnetic resonance. Use of TMS as a standard. Recognition of chemically equivalent hydrogen atoms. Use of chemical shifts (from tables), peak integration and spin-spin splitting to suggest a molecular structure from a ^1H n.m.r. spectrum (limited to simple organic compounds containing six or less carbon atoms).

Infra-red Spectroscopy

Understanding that absorption of radiation arises from molecular vibrations. The use of infra-red spectra to elucidate molecular structure by identifying simple functional groups using tables of characteristic wave numbers.

Ultra-violet and visible spectroscopy

Understand that ultra-violet/visible absorption of radiation arises from electronic transitions between energy levels. Know that molecules with extended delocalised electron systems (conjugation) are likely to absorb light in the visible region and thus appear coloured.

The use of ultra-violet/visible spectra to elucidate molecular structure by identifying simple functional groups using tables of characteristic wavelengths.

The meaning of the term chromophore. Explanation of the colour changes in acid-base indicators such as methyl orange in terms of a change in the chromophores.

Volumetric Analysis

Simple examples of back titration including determination of the purity of a Group II carbonate and of the percentage of ammonia in an ammonium salt.

Use of double indicator method to determine the composition of a mixture such as sodium hydrogencarbonate/sodium carbonate.

Use of edta to determine (separately) magnesium and copper ions in solution. Names and colour changes of indicators.

Colorimetry

The use of colorimetry to determine the percentage of iron in aluminium foil and, by Job's method, the formula of a complex such as that between copper (II) ions and ammonia. (The theory of colorimetry is not required.)

Chromatography (theory excluded)

Simple experiments to illustrate paper and thin-layer chromatography (on prepared plates) leading to an understanding of R_f values; two way chromatography. The commercial and research values of the above techniques and GLC.

5.2 Transition elements (from Ti to Cu, with specific reference to Cr and Fe)

General characteristics such as incomplete d-shell, metallic nature, variable oxidation states, catalytic action, formation of coloured aqua and other complexes. Application of VSEPR to predict shapes of ions etc. mentioned below.

Changes of oxidation state

Preparation of chrome alum by reduction of potassium dichromate, and preparation of potassium dichromate by oxidation of a chromium (III) salt.

The oxidation of Fe (II) to Fe (III) using chlorine and using H_2O_2 . The reduction of Fe (III) to Fe (II) using zinc and dilute acid and using sulphites.

Titration of iron (II) with acidified manganate (VII).

Complexes

Complexes understood as consisting of a central metal atom or ion surrounded by a number of ligands, defined as anions or molecules possessing lone pairs of electrons. Coordination number. Spatial arrangement of the bonds from the ligands to the central atom or ion up to six outer electron pairs. The geometric isomerism of square planar platinum complexes eg cisplatin. The use and mode of action of cisplatin as an anti-cancer drug.

Colours in solution of the hexa-aqua complexes of Cr^{3+} , Mn^{2+} , Fe^{2+} , Fe^{3+} , Co^{2+} , Ni^{2+} , Cu^{2+} . The use as qualitative detection tests of the formation of precipitates of the hydroxides of these metals with $NaOH(aq)$ and $NH_3(aq)$ and, where appropriate, their subsequent dissolution.

Experimental study of the formation of complexes from the hexa-aqua cations viewed as a step-wise ligand replacement reactions. The use of stability constants to determine the feasibility of ligand replacements. Stability constants are to be regarded as equilibrium constants which can be for overall ligand replacement or for individual steps which multiply to give the overall constant. (Alternatively their logs may be added.) By convention, water being present in excess is not included in the stability constant expression. (Candidates will not be expected to quote names of complexes.)

Colours, formulae and use in qualitative detection tests of $[CuNH_3)_4(H_2O)_2]^{2+}$, $[CoCl_4]^{2-}$, $[Fe(CN)_6]^{3-}$, $[Fe(CN)_6]^{4-}$, $[Fe(SCN)(H_2O)_5]^{2+}$, $[Ni(NH_3)_6]^{2+}$, $[CuCl_4]^{2-}$, $[Co(NH_3)_6]^{2+}$. Distinction between monodentate and chelating ligands, 1, 2-diaminoethane and edta as examples of chelating ligands. Formation and colours of $[Ni(en)_3]^{2+}$ and $[Ni(edta)]^{2-}$.

Catalytic Behaviour (See also section 2.8)

The use of transition metals as heterogeneous catalysts, such as nickel in the hydrogenation of C=C double bonds. The action of transition element ions with variable oxidation states as homogeneous catalysts, illustrated by the catalysis of the decomposition of OCl^- ions to O_2 by Co^{2+} .

5.3 Arenes

Petroleum as the industrial source of benzene (details of the reforming process not required).

Structure and shape of the benzene molecule to include reference to the delocalised π electrons. (No reference to hybridisation is necessary.)

Comparison between the reactivities of benzene and an alkene related to bond type and bond enthalpy. The resistance of benzene to addition of bromine and comparison with an alkene.

Monohalogenation of benzene by Br_2 and a catalyst; mononitration by concentrated HNO_3 and concentrated H_2SO_4 .

The mechanism of the formation of nitrobenzene from benzene viewed as electrophilic substitution.

Preparation of methyl 3-nitrobenzoate from methyl benzoate to illustrate nitration of the benzene ring.

5.4 Amines (restricted to primary aliphatic amines and phenylamine)

Formation of primary aliphatic amines by reduction of nitriles using LiAlH_4 and by the reaction of ammonia on alkyl halides. Formation of phenylamine by reduction of nitrobenzene using tin and hydrochloric acid, to the phenylammonium salt (practical experience and details of the anion not required), followed by liberation of the free amine by addition of alkali.

Reference to the effect of hydrogen bonding on boiling point and solubility in water.

Formation of salts with mineral acids. Relative basic strengths of ammonia, primary aliphatic amines, phenylamine.

Reaction with ethanoyl chloride and the use of this reaction to identify unknown amines.

Reaction of ethylamine and phenylamine with nitrous acid. Comparison of the stability of the diazonium ion formed.

Formation of benzene diazonium chloride from phenylamine and its conversion to phenol and to iodobenzene. Coupling with phenol. Knowledge of use of azo-compounds as dyestuffs and indicators.

5.5 Amino Acids (restricted to α -amino acids) and proteins

Formulae of glycine and alanine only.

Optical activity of alanine.

Solubility in water and relatively high melting point due to existence as dipolar ions.

Reactions with Na_2CO_3 , CuSO_4 and HNO_2 .

Proteins regarded as a sequence of amino acids joined by the peptide link.

Primary, secondary and tertiary structure of proteins. Enzymes. Lock and key mechanism to explain enzyme action. Effect of pH and temperature on their activity.

5.6 Nitriles

Formation from alkyl halides. Use in increasing the length of a carbon chain.

Acid or base catalysed hydrolysis to form carboxylic acids or their salts.

Reduction with LiAlH_4 to form primary amines.

4 GRADE DESCRIPTIONS

The following grade descriptions indicate the level of attainment characteristic of the given grade at Advanced Level. They give a general indication of the required learning outcomes at each specific grade. The descriptions should be interpreted in relation to the specified subject content; they are not designed to define that content. The grade awarded will depend in practice upon the extent to which the candidate has met the assessment objectives overall. Shortcomings in some aspects of the examination may be balanced by better performance in others.

GRADE A

Candidates recall and use chemical knowledge from the whole specification with few significant omissions and show good understanding of the principles and concepts they use. They are thoroughly conversant with the construction of chemical equations and use them quantitatively in a range of contexts. They select chemical knowledge relevant to most situations and present their ideas clearly and logically, making use of appropriate chemical terminology.

Candidates carry out calculations in a logical manner even when little guidance is given. They demonstrate good understanding of principles, applying them in familiar and new contexts, for example, in determining the order of reaction from empirical results, in predicting the conditions which might be used in an industrial process, in using knowledge of the periodic table to predict reactions of unfamiliar elements or compounds or in predicting the reactions of organic compounds containing specific functional groups. They bring together and use knowledge and understanding from more than one area of the specification, for example, in suggesting a method for synthesising a particular compound or in interpreting evidence relating to the structure of a molecule or ion.

In experimental activities, candidates independently formulate a clear and accurate plan. They use a range of manipulative techniques safely and skilfully, making and recording observations with appropriate precision. They interpret, explain and evaluate results, using appropriate chemical knowledge and terminology.

GRADE C

Candidates recall chemical knowledge from many parts of the specification and show good understanding of some functional principles and concepts. They routinely represent most reactions, for example, those for inorganic redox processes, by chemical equations and use them quantitatively. They frequently select chemical knowledge relevant to a particular situation or context and present their ideas clearly and logically, making use of chemical terminology.

Candidates carry out a range of calculations, making progress in some where little guidance is given. They show knowledge of fundamental principles in applying these in some new contexts, for example, in using information about reactions to distinguish between compounds containing different functional groups. They bring together information from more than one area of the specification in interpreting information, for example, in explaining trends in K_a , for a range of organic acids.

In experimental activities, candidates formulate a plan which may need some modification. They use a range of techniques safely, making and recording observations and measurements which are adequate for the task. They interpret and explain experimental results, relating these to chemical knowledge and understanding and, with help, evaluate how good their results are.

GRADE E

Candidates recall chemical knowledge from some parts of the specification and demonstrate some understanding of fundamental principles and concepts, for example, in relating the properties of some compounds to the bonding found in them. They write chemical equations for straightforward, frequently-encountered chemical reactions and use simple equations quantitatively. They select discrete items of knowledge in response to structured questions and use basic chemical terminology.

Candidates carry out straightforward calculations where guidance is given. They apply knowledge and chemical principles contained within the specification to material presented in a familiar or closely related context, for example, in using information about reactions to identify the functional groups in some organic compounds. They use some fundamental chemical skills in contexts which bring together different areas of the subject.

In experimental activities, candidates formulate some elements of a practical approach when provided with guidance. They carry out frequently encountered practical procedures in a reasonably skilful manner, recognising the risks in familiar procedures and obtain some appropriate results. They interpret and explain some experimental results but need assistance to relate these to chemical knowledge and understanding.

5 GUIDANCE FOR TEACHERS ON INTERNAL ASSESSMENT AND EXTERNAL MODERATION

5.1 INTRODUCTION

These notes for guidance relate to the internal assessment component which is to be conducted by the teacher during practical activities arising from his/her normal teaching programme. Information technology should be used, where appropriate, to collect and process data, and to communicate results.

5.1.1 For the award of an A Level, each candidate is to be assessed in the following four skill areas:

- 1 Manipulating, measuring and recording.
- 2 Manipulating, observing and recording.
- 3 Concluding and communicating in a quantitative experiment.
- 4 Concluding and communicating in a qualitative experiment.

Each of the skill areas will be assessed on a ten-point scale using the assessment criteria described in Section 5.2 below.

5.1.2 The assessment of practical skills through internal assessment contributes 6.7% of the total assessment.

5.2 ASSESSMENT CRITERIA

The criteria described below should be used for the award of marks in each of the skill areas.

Each assessment criterion is marked on a scale of 0-2 where:

2: criterion is fully met without teacher assistance

1: criterion is only partly met, or fully met after a little teacher assistance*

0: criterion is not met or met only after further teacher assistance.

Half marks **cannot** be used.

(*See Section 5.3.7 regarding teacher assistance).

Skill 1: Manipulation, measuring and recording

This skill area should be assessed in a context in which a titration* is used as one stage in a more detailed experiment eg kinetics, equilibrium or solubility.

Marks should be awarded where the candidate:

Assessment Criteria	Max. Mks Available
(i) chooses appropriate apparatus and demonstrates full competence in setting up, and dexterity in operating, all the apparatus used in an experiment;	2
(ii) takes all sensible precautions to ensure the safety of personnel and the maintenance and conservation of equipment;	2
(iii) during the titration step, makes measurements to a high degree of precision ie 2 or more titres agree within 0.1 cm ³ ;	2
(iv) during the titration step, repeats sufficient readings to ensure a suitable level of accuracy ie average titre within 0.1 cm ³ of the teacher identified value;	2
(v) clearly displays and neatly presents results to an appropriate and consistent number of significant figures with units indicated and using a table where necessary. (The table should not be provided by the teacher.) Where appropriate, uses IT for the logging and processing of data.	2
	10

(*A titration is understood to involve pipetting, using a burette and determining an end-point.)

Skill 2: Manipulation, observing and recording

A minimum of 10 observations will be required to meet this skill. This skill may be carried out using more than one substance and should incorporate both organic and inorganic aspects.

Marks should be awarded where the candidate:

Assessment Criteria	Max. Mks Available
(i) demonstrates full competence and dexterity in operating all the apparatus used in an experiment;	2
(ii) makes all relevant observations of colour changes and the formation and colour of precipitates;	2
(iii) accurately observes the evolution of gases and performs suitable tests to identify them where necessary;	2
(iv) accurately observes all other changes such as temperature, the appearance of substances, smells and so on;	2
(v) clearly expresses and neatly displays the record of observations.	2
	10

Skill 3: Concluding and Communicating (Quantitative)

Results from the experiment used to assess Skill 1 may be used to assess this skill area.

In an experiment *involving a titration*, marks should be awarded where the candidate:

Assessment Criteria	Max. Mks Available
(i) manipulates all data correctly, including the use of graphs where appropriate, and accurately calculates the outcome;	2
(ii) draws appropriate conclusions in relation to the problem set and uses chemical knowledge to explain these conclusions;	2
(iii) critically evaluates the results obtained, identifying any errors and where necessary ignores them in drawing conclusions;	2
(iv) suggests improvements to the experiment in light of (iii) above;	2
(v) clearly and concisely presents all conclusions, using appropriate nomenclature and terminology, to an appropriate number of significant figures and with correct use of language.	2
	10

Skill 4: Concluding and Communicating (Qualitative)

Results from the experiment used to assess Skill 2 may be used to assess this skill area.

In a qualitative experiment, marks should be awarded where the candidate:

Assessment Criteria	Max. Mks Available
(i) interprets qualitative observations correctly;	2
(ii) draws appropriate conclusions in relation to the problem set and uses chemical knowledge to explain these conclusions;	2
(iii) critically evaluates the results obtained, identifies any conflicts or ambiguities in them and where necessary ignores them in drawing conclusions;	2
(iv) suggests improvements or additions to the original experiment in light of (iii) above;	2
(v) clearly and concisely presents all conclusions, using appropriate nomenclature and terminology, with correct use of language.	2
	10

5.3 MAKING ASSESSMENTS

- 5.3.1 Candidates should be made aware at the beginning of the course that their individual practical work will be assessed for examination purposes.
- 5.3.2 Teachers are advised to carry out assessments in experimental situations with which candidates have some familiarity, but candidates are not to be rehearsed in particular experiments which are further repeated for the purpose of assessment.
- 5.3.3 The Council will publish suitable experiments and mark schemes for assessment purposes.
- 5.3.4 Teachers are free to devise their own practical work, within the limitations set out in the previous paragraphs. Centres **must** confirm with the Council that any assessments they propose, with related mark schemes, satisfy the requirements of this specification. It is realised that practical work set by an individual teacher will differ from that set by other teachers depending on the facilities and resources available. However, centres should be aware of the requirement for internal moderation and standardisation so that a consistent approach by teachers within individual centres is achieved.
- 5.3.5 Candidates' work **must** be annotated **in detail** showing where mark descriptors for assessment criteria within each skill were satisfied.
- 5.3.6 Assessments should take place as appropriate during normal laboratory teaching rather than by means of end-of-session practical examinations. Teachers are free to choose when to carry out assessment through the course.
- 5.3.7 The teacher must exercise control and supervision of all practical work on which the assessments are carried out to ensure that the work assessed is that of the individual candidate concerned. Work done at home should not be used for assessments. Experiments assessed should be carried out by the candidate working individually, not as a member of a group, though pooling of class results for the purpose of individual interpretation is permissible.

Guidance to candidates may be given by the teacher as follows:

- (i) minor assistance which is penalised by 1 mark so that the maximum available mark under this assessment criterion is 1;
- (ii) further assistance or direct instructions in order to be able to attempt any part of a skill area results in the candidate being awarded no marks (see Section 5.2 above).

Teachers will be required to sign a declaration to certify that, to the best of their knowledge, all the work submitted for assessment is the candidate's own.

5.4 RECORDING ASSESSMENTS

Teachers may make as many assessments of each of the skill areas as they wish but a minimum of **two** should be recorded on the individual record sheet. The **best** assessment in any skill area should be circled used to calculate the final total mark. Such individual record sheets should be completed for each candidate. The forms will be supplied by the Council.

5.5 MODERATION OF ASSESSMENTS

Centres will be required to submit selected samples of candidates' coursework, chosen according to criteria supplied annually by the Council. Mark schemes showing how the mark descriptors for each skill were satisfied **must** also be submitted for moderation. This will act as a safeguard for the candidates should the moderators disagree with the circled marks.

Prior to moderation, centres **must** ensure that a process of internal standardisation has been carried out since adjustments made during moderation will apply to all candidates from any centre.

Agreement trials will be conducted annually, prior to the date of submission of coursework samples, where teachers will be briefed on the application of the assessment criteria and will engage in trial marking.

6 RESOURCE LIST

The following list is an indication of books and other resources which teachers and students may find useful in teaching and studying a course based on this specification. It is not intended to be a list of prescribed texts, nor is it intended to be an exhaustive list of all available resources.

Title	Author	Publisher	ISBN
Heinemann Advanced Science: Chemistry	Fullick, A & Fullick, P	Heinemann (1994)	0435 570803
Chemistry (Bath Science 16-19)	Gadd, K & Gun, S	Nelson	0 17448 236 1
Chemistry in Context (Fourth Edition)	Hill, G and Holman, J	Nelson	0 17448191 8
Advanced Chemistry	J Maple	John Murray	0 7195 5359 8
A Level Chemistry	Ramsden, E N	John Murray	0 7487 1688 2
The Consumer's Good Chemical Guide	Emsley, J	W H Freeman	0 7167 4505 4
Molecules at an exhibition	Emsley, J	Oxford University Press	0 19 850200 4
The Extraordinary Chemistry of Ordinary Things	Snyder, C H	John Wiley (1997)	0-471-17905-1
The Periodic Kingdom	Atkins, P	Weidenfield and Nicolson	0 85404 945 2
Chemistry in the Market Place	Selinger, B	John Murray	0 7195 3617 0
The Age of the Molecule	Royal Society of Chemistry	Royal Society of Chemistry (1999)	0 85404 945 2
In Search for More Solutions	Taylor, J	Royal Society of Chemistry (1995)	0 870343 35 2
Biochemistry and Food Science	Ramsden, E N	Stanley Thornes (1995)	0 7487 18060
The Chemistry of the Environment	Ramsden, E N	Stanley Thornes	0 7487 2400 1

Title	Author	Publisher	ISBN*
Understanding our Environment	Harrison, R M	Royal Society of Chemistry (1992)	0 85186 233 0
Environmental Science	Jackson, A R W & Jackson, J M	Longman (1996)	0 582 22709 7
Environmental Chemistry (3rd Edition)	O'Neill, P	Stanley Thornes (1998)	0-7514-0483-7
Environmental Chemistry	Ramsden, E N	Stanley Thornes (1996)	0 7487 24 00 2
Modern Chemical Techniques	Faust, C B	Royal Society of Chemistry (1992)	1 87034319 0
Advanced Chemistry – Book 1 Physical and Industrial Chemistry	Matthews	Cambridge	0 521 42332 5
Advanced Chemistry – Book 2 Inorganic and Organic Chemistry	Matthews	Cambridge	0 521 42333 3
Chemistry in Action	M Freemantle	Macmillan	0-333-56515-0
Chemical Nomenclature, Symbols and Terminology for use in School Science		ASE	0 86357 013 5
Safeguards in the School laboratory 10th edition		ASE 1996	0 86357 250 2

USEFUL WEB SITES

Links to chemistry sites	www.chemists-net.demon.co.uk/ www.chemdex.org/
Periodic Tables	www.shef.ac.uk/chemistry/web-elements
Interesting science with links to web sites	www.chemsoc.org/viselements/ www.newscientist.com
Software Rasmol: Free software for looking at molecular structures of biochemical molecules	www.umass.edu/microbic/rasmol
ISIS/DRAW: Free chemical drawing software	www.mdll.com/

APPENDIX 1

OPPORTUNITIES FOR DEVELOPING AND GENERATING EVIDENCE FOR ASSESSING KEY SKILLS

The following table signposts and exemplifies the types of opportunity for developing and generating evidence for assessing key skills that may arise during an AS/ A level course in Chemistry. The opportunities are referenced to Section B of the relevant key skills specifications at Level 3. The subject exemplifications illustrate typical opportunities which may arise during the normal teaching and learning process. These are only a small selection of such opportunities and are not part of the key skills specifications themselves. It is for teachers and students to decide which pieces of work, if any, to use to develop and assess key skills.

KEY SKILLS

The Government and the Examination Awarding bodies are committed to the delivery of a range of Key Skills. GCE Chemistry has been identified as a vehicle for contributing to the delivery of the following skills.

Communication

In this the student must demonstrate that they can:

- take part in discussions;
- make a presentation;
- select and synthesise information;
- write about complex subjects.

Application of Number

In this the student must demonstrate that they can:

- plan an activity and interpret information from different sources;
- carry out multi-stage calculations;
- present findings, explore results and justify choice of method.

Information Technology

In this the student must demonstrate that they can:

- compare and use different sources to find information and make selections;
- explore, develop and exchange information, and derive new information;
- present information, including text, numbers and images.

Working with others

In this the student must demonstrate that they can:

- plan work, agreeing objectives, responsibilities and working arrangements;
- seek to establish and maintain cooperative working relationships;
- review work and agree ways of improving future collaborative work.

Improving own learning and performance

In this the student must demonstrate that they can:

- agree targets and plan how these will be met;
- use your plan, seeking feedback and support from others, to help meet targets;
- review your progress and establish evidence of your achievements.

Problem solving

In this the student must demonstrate that they can:

- explore problems, compare different ways of solving them and select options;
- plan and implement options;
- apply agreed methods for checking problems have been solved and review approaches to tackling problems.

Key Skill: Communication

Key Skills Specification Part B Reference		
Activity	Evidence	Subject Exemplification
C3.1a Contribute to group discussion about a complex subject.	<ul style="list-style-type: none"> ■ make clear and relevant contributions in a way that suits your purpose and situation; ■ listen and respond sensitively to others and develop points and ideas; and ■ create opportunities for others to contribute when appropriate. 	2.2 Hydrocarbons - environmental problems associated with oil spillage and combustion of hydrocarbons.
C3.1b Make a presentation about a complex subject using at least one image to illustrate complex points.	<ul style="list-style-type: none"> ■ speak clearly and adapt your style of presentation to suit your purpose, subject, audience and situation. ■ structure what you say so that the sequence of information and ideas may be easily followed; and ■ use a range of techniques to engage the audience, including effective use of images. 	<p>Make a presentation explaining the essential chemistry in the following sections:</p> <p>2.8 Collision theory.</p> <p>1.2 Ionic bonding.</p> <p>4.6 Distinguishing between aldehydes and ketones.</p> <p>5.3 Comparison between reactivities of benzene and an alkene.</p>
C3.2 Read and synthesise information from two extended documents about a complex subject. One of these documents should include at least one image.	<ul style="list-style-type: none"> ■ select and read material that contains the information you need; ■ identify accurately and compare, the lines of reasoning and main points from texts and images; and ■ synthesise key information in a form that is relevant to your purpose. 	<p>1.8 The Periodic Table: The historical development of this.</p> <p>1.2 Metals: The basis for classifying elements as metals.</p> <p>4.11 Manufacture of H₂SO₄, HNO₃, H₃PO₄: Summarise and compare the manufacture of these acids and their uses, emphasising quantities and scale of operation.</p>
C3.3 Write two different types of documents about complex subjects. One piece of writing should be an extended document and include at least one image.	<ul style="list-style-type: none"> ■ select and use a form and style of writing that is appropriate to your purpose and complex subject matter; ■ organise relevant information clearly and coherently using specialist vocabulary when appropriate; and ■ ensure your text is legible and your spelling and punctuation are accurate, so your meaning is clear. 	<p>Writing documents</p> <p>2.2 Hydrocarbons: write an essay on world sources of hydrocarbons, their uses, and long term viability as energy sources.</p> <p>2.8 Catalysis: write an essay outlining the theory and use of catalysts giving consideration to economic aspects of their use.</p> <p>5.1 Analytical techniques: write an essay outlining the use of some analytical techniques in structural elucidation of some compounds.</p>

Key Skill: Application of Number

Key Skills Specification Part B Reference		
Activity	Evidence	Subject Exemplification
N3.1 Plan and interpret information from two different types of sources, including a large data set.	<ul style="list-style-type: none"> ■ plan how to obtain and use the information required to meet the purpose of your activity; ■ obtain the relevant information; and ■ choose appropriate methods for obtaining the results you need and justify your choice. 	1.8 The Periodic Table: Plan to obtain and interpret trends in physical properties for the elements in Groups 1, 2, 4, 5, 6 and 7, across periods 1, 2 and 3 and Transition Elements. Such properties could include density, melting point, boiling point and first ionisation energies. 2.6 Alcohols: Plan to obtain and interpret trends in physical properties and their relationship with molecular structure. Such properties could include: melting point, boiling point, density and enthalpy of combustion for odd and even number carbon alcohols, isomers, and primary, secondary and tertiary alcohols.
N3.2 Carry out multi-stage calculations to do with: a amounts and sizes; b scales and proportions; c handling statistics; d rearranging and using formulae. You should work with a large data set on at least one occasion.	<ul style="list-style-type: none"> ■ carry out calculations to appropriate levels of accuracy, clearly showing your methods; ■ check methods and results to help ensure errors are found and correct. 	Calculations Calculation of empirical and molecular formula. Calculation of reacting masses and volumes. Percentage yields. 1.9/5.1 Titrations 4.2 Rate equations 4.3 Equilibrium calculations; Partition Coefficient 4.1 Lattice Energies
N3.3 Interpret results of your calculations and justify your methods. You must use at least one graph, one chart and one diagram.	<ul style="list-style-type: none"> ■ select appropriate methods of presentation and justify your choice; ■ present your findings effectively; and ■ explain how the results of your calculations relate to the purpose of your activity. 	Present and interpret the results of the above calculations

Key Skill: Information Technology

Key Skills Specification Part B Reference		
Activity	Evidence	Subject Exemplification
IT3.1 Plan, and use different sources to search for, and select, information required for two different purposes.	<ul style="list-style-type: none"> ■ plan how to obtain and use the information required to meet the purpose of your activity; ■ choose appropriate sources and techniques for finding information and carry out effective searches; and ■ make selections based on judgements of relevance and quality. 	The Northern Ireland Network for Education (NINE) lists many sites which can provide information for the delivery of this Key Skill. Plan, select information 1.8 Database on the Periodic Table: Obtain and interpret trends in physical properties of elements across the period sodium to argon. 2.6 Database on Alcohols: Obtain and interpret trends in physical properties and their relationship with molecular structure
IT3.2 Explore, develop and exchange information and derive new information to meet two different purposes.	<ul style="list-style-type: none"> ■ enter and bring together information in a consistent form, using automated routines where appropriate; ■ create and use appropriate structures and procedures to explore and develop information and derive new information; and ■ use effective methods of exchanging information to support your purpose. 	
IT3.3 Present information from different sources for two different purposes and audiences. Your work must include at least one example of text, one example of images and one example of numbers.	<ul style="list-style-type: none"> ■ develop the structure and content of your presentation using the views of others, where appropriate, to guide refinements; ■ present information effectively, using a format and style that suit your purpose and audience; and ■ ensure your work is accurate and makes sense 	Present information using OHPs/ Powerpoint to give a presentation to class on various topics e.g. 1.3 Shapes of molecules, 1.2 electronic configuration, 4.3 titration curves. Construction of flow charts for e.g. 4.11 industrial preparation of acids, 5.3 mechanism for the formation of nitrobenzene

Key Skill: Working with Others

Key Skills Specification Part B Reference		
Activity	Evidence	Subject Exemplification
WO3.1 Plan complex work with others, agreeing objectives, responsibilities and working arrangements.	<ul style="list-style-type: none"> ■ agree realistic objectives for working together and what needs to be done to achieve them; ■ exchange information, based on appropriate evidence, to help agree responsibilities; and ■ agree suitable working arrangements with those involved. 	<p>Students could be asked to work on an information research and presentation task working as a group of three or four. For example, they may be asked to gather information about problems associated with hydrocarbon combustion (2.2), air pollution as a wider topic (2.8) and alcohol as an alternative energy source (2.6) with a view to making a presentation to the class in order to educate other students about that part of the specification. They may also be asked to produce and present to each member of class a set of notes to support the teacher in the provision of materials on the above topics. To do this students would need a detailed task specification from the teacher and would then meet, discuss and record the objectives of the task, the responsibilities of each member of the group and the actions and resources needed to achieve those objectives. They would also have to agree and record where the work would be done and produce a schedule of working arrangements for the group.</p>
WO3.2 Seek to establish and maintain cooperative working relationships over an extended period of time, agreeing changes to achieve agreed objectives.	<ul style="list-style-type: none"> ■ organise and carry out tasks so you can be effective and efficient in meeting your responsibilities and produce the quality of work required; ■ seek to establish and maintain cooperative working relationships, agreeing ways to overcome any difficulties; and ■ exchange accurate information on progress of work, agreeing changes where necessary to achieve objectives. 	<p>Having agreed and shared out the responsibilities associated with the task individual students should carry out their part of the work in a thorough manner, gathering and recording information in a way which will make it easily understandable but sufficiently detailed to be of value as part of the learning and examination process</p> <p>Students should meet during the information gathering period to review progress and agree ways to overcome difficulties.</p> <p>Records of such meetings should be kept as evidence that the students have been working together. These records may be on pro forma which should relate progress to previously agreed action plans and objectives.</p>

Key Skills Specification Part B Reference		
Activity	Evidence	Subject Exemplification
WO3.3 Review work with others and agree ways of improving collaborative work in the future.	<ul style="list-style-type: none"> ■ agree the extent to which work with others had been successful and the objectives have been met; ■ identify factors that have influenced the outcome; and ■ agree ways of improving work with others in the future. 	<p>Students may meet with the teacher to review the activity against the objectives and to suggest alternative approaches which may be more successful.</p> <p>After the presentation to the class group students may receive and record feedback from the class group about how things could have been done differently to enhance the collaborative dimension of the work</p>

Key Skill: Improving own Learning and Performance

Key Skills Specification Part B Reference		
Activity	Evidence	Subject Exemplification
LP3.1 Agree targets and plan how these will be met over an extended period of time, using support from appropriate people.	<ul style="list-style-type: none"> ■ seek information on ways to achieve what you want to do, and identify factors that might affect your plans; ■ use this information to agree realistic targets with appropriate people; and ■ plan how you will effectively manage your time and use of support to meet targets, including alternative action for overcoming possible difficulties. 	<p>Set targets to improve note-taking skills and analysis of question demands (all modules).</p> <p>Summarise the subject content of the specification in flow chart form and check level of detail with your teacher eg the interconnections in organic chemistry backed up by appropriate practical work.</p>
LP3.2 Take responsibility for your learning by using your plan, and seeking feedback and support from relevant sources, to help meet targets. Improve your performance by: studying a complex subject; learning through a complex practical activity; further study or practical activity that involves independent learning.	<ul style="list-style-type: none"> ■ prioritise action and manage your time effectively to complete tasks, revising your plan as necessary; ■ seek and actively use feedback and support from relevant sources to help you meet targets; and ■ select and use different ways of learning to improve your performance, adapting approaches to meet new demands. 	<p>Examine questions from past papers and discuss with your teacher your interpretation of what is being demanded. Check these against published mark schemes</p>
LP3.3 Review progress on two occasions and establish evidence of achievements, including how you have used learning from other tasks to meet new demands.	<ul style="list-style-type: none"> ■ provide information on the quality of your learning and performance, including factors that have affected the outcome; ■ identify targets you have met, seeking information from relevant sources to establish evidence of your achievements; and ■ exchange views with appropriate people to agree ways to further improve your performance. 	<p>Review progress by means of feedback from the teacher and your ability to produce flow charts, unaided, relating to subject content eg rates of reaction including handling and interpretation of data.</p>

Key Skill: Problem Solving

Key Skills Specification Part B Reference		
Activity	Evidence	Subject Exemplification
PS3.1 Explore a complex problem, come up with three options for solving it and justify the option selected for taking forward.	<ul style="list-style-type: none"> ■ explore the problem, accurately analysing its features, and agree with others on how to show success in solving it; ■ select and use a variety of methods to come up with different ways of tackling the problem; and ■ compare the main features of each possible option, including risk factors, and justify the option you select to take forward. 	<p>Devise a plan to find the percentage of copper in brass. You may assume that the only two metals present in brass are copper and zinc. The brass can be dissolved in concentrated nitric acid.</p> <p>Copper (II) ions but not zinc ions react with iodide ions according to</p> $2\text{Cu}^{2+} + 4\text{I}^- \rightarrow 2\text{CuI} + \text{I}_2$ <p>The liberated iodine can be determined by titration.</p> <p>The percentage of copper in brass is between 65 and 80%.</p>
PS3.2 Plan and implement at least one option for solving the problem, review progress and revise your approach as necessary.	<ul style="list-style-type: none"> ■ plan how to carry out your chosen option and obtain agreement to go ahead from an appropriate person; ■ implement your plan, effectively using support and feedback from others; and ■ review progress towards solving the problem and revise your approach as necessary. 	<p>Plan an experiment which would enable you to find the order of reaction with respect to any one reactant for the reaction.</p> $2\text{H}^+ + \text{H}_2\text{O}_2 + 2\text{I}^- \rightarrow \text{I}_2 + 2\text{H}_2\text{O}$ <p>You should include amounts and concentrations of solutions to be used, apparatus required and an outline of the procedure. A brief indication of the calculation should be given, including graphs to be drawn.</p> <p>(Alternatively it could be said that suitable concentrations are $0.025 \text{ mol dm}^{-3}$ sodium thiosulphate, 1 mol dm^{-3} sulphuric acid and 1 mol dm^{-3} potassium iodide.)</p>
PS3.3 Apply agreed methods to check if the problem has been solved, describe the results and review your approach to problem solving.	<ul style="list-style-type: none"> ■ agree, with an appropriate person, methods to check if the problem has been solved; ■ apply these methods accurately, draw conclusions and fully describe the results; and ■ review your approach to problem solving, including whether alternative methods and options might have proved more effective. 	<p>Commercial lemon juice or lemon squash contains citric acid. This gives the lemony taste. Citric acid is a tricarboxylic acid with the molecular formula $\text{C}_6\text{H}_8\text{O}_7$ and is a weak acid. You are required to devise a 'value for money' plan in terms of 'most acid represents best value' for a series of juices. You may assume that there is no other acid present in the juice.</p>

Key Skills Specification Part B Reference		
Activity	Evidence	Subject Exemplification
		<p>To be commercially viable for use as a source of iron via the blast furnace, an ore must contain 80% Fe₂O₃.</p> <p>You are supplied with an iron ore and you must plan a method to establish if it is viable using the above criterion. Your plan should include apparatus and reagents (including suitable amounts), safety aspects and an indication of how you would calculate the iron content.</p> <p>(GPR iron (III) oxide and sand mixed. Modification of thiocyanate colorimetric method or reduction to iron (II) and titration with permanganate.)</p> <p>The preparation of magnesium oxide by direct combustion of the metal in air is not reliable because during the burning some of the oxide may escape and also some of the metal may react with the nitrogen in the air. Consequently the product will not conform to the expected formula. However, magnesium is soluble in dilute nitric acid and the magnesium nitrate formed will decompose on strong heating to form magnesium oxide as the only solid product with oxygen and nitrogen dioxide being given off as gases.</p> <p>By using the method described, or another of your own choosing, plan how to establish the formula of magnesium oxide.</p>