Contents

WJEC Advanced Subsidiary GCE in Chemistry
WJEC Advanced GCE in Chemistry

2007 & 2008

GCE CHEMISTRY

Subject/Option Entry Codes	
Advanced Subsidiary (AS) "Cash in" entry *Advanced Level (AL) "Cash in" entry*	*330 80* *330 90*
Unit CH1	331 01
Unit CH2	332 01
Unit CH3(a + b)	333 01
Unit CH3(a + c)	333 02
Unit CH4	334 01
Unit CH5	335 01
Unit CH6 (a + b)	336 01
Unit CH6 (a + c)	336 02

When making entries, the codes listed should be prefixed with a '0' for English medium entries and with a 'W' for Welsh medium entries

Assessment units CH1, CH2 and CH4 will be available in January and June. Units CH3, CH5 and CH6 will be available in June only. The assessment calendar is shown below.

Availability of Assessment Units

Unit	**January 2004 & each subsequent year**	**June 2004 & each subsequent year**
CH1	✓	✓
CH2	✓	✓
CH3		✓
CH4	✓	✓
CH5		✓
CH6		✓

SUMMARY OF ASSESSMENT

ADVANCED SUBSIDIARY

Assessment Unit	Content	Time	Marks Available	Weighting			
				%AS		%A	
CH1	Physical - Inorganic Paper	1 hr 30 mins	66	35.0 %		17.5 %	
CH2	Physical - Organic Paper	1hr 30 mins	66	35.0 %		17.5 %	
CH3a	Theory – Experimental Interface Paper	45 mins	30	10.0 %	30 %	5.0 %	15 %
EITHER CH3b	Coursework (Internally marked – externally moderated)	N/A	103	20.0 %		10.0 %	
OR CH3c	Coursework (Externally set and marked)	N/A	103	20.0%		10.0%	

- Assessment units CH1, CH2 and CH3a will be externally set and assessed by the Board.
- Assessment unit CH3b will contain two internally set experiments (Board pre-approved), internally marked and moderated by the Board.
- Assessment unit CH3c will contain two experiments that are externally set and marked by the Board.

ADVANCED

Assessment Unit	Content	Time	Marks Available	Weighting	
CH4	Spectroscopy & Further Organic Chemistry Paper	1hr 40 mins	75	15.0 %	
CH5	Further Physical & Inorganic Chemistry Paper	1hr 40 mins	75	15.0 %	
CH6a	Synoptic Paper	1hr 10 mins	50	10.0 %	20.0 %
EITHER CH6b	Coursework (Internally marked – externally moderated)	N/A	103	10.0 %	
OR CH3c	Coursework (Externally set and marked)	N/A	103	10.0%	

- Assessment units CH4, CH5 and CH6a will be externally set and assessed by the Board.
- Assessment unit CH6b will contain two internally set experiments (Board pre-approved), internally marked and moderated by the Board.
- Assessment unit CH6c will contain two experiments that are externally set and marked by the Board.

SUMMARY OF CONTENT

Modules CH1 and CH2 contain the AS subject core and include unifying ideas such as bonding and structure, energetics, equilibria and the Periodic Table. These concepts are required for the understanding of modules CH4 and CH5 and the appreciation of chemistry as a coherent subject. The subject core unique to A2 is contained within modules CH4 and CH5.

ADVANCED SUBSIDIARY

Module CH1

Topic 1	Atomic Structure
Topic 2	The Mole and Stoichiometry
Topic 3	Structure and Bonding
Topic 4	Gases, Liquids and Solids
Topic 5	The Periodic Table

Module CH2

Topic 6	Principles of Energetics
Topic 7	Organic Compounds: Nomenclature; Isomerism; Reaction Types and Functional Groups
Topic 8	Hydrocarbons and Petroleum
Topic 9	Principles of Chemical and Acid-Base Equilibria
Topic 10	Chemical Kinetics
Topic 11	Industrial and Environmental Aspects

ADVANCED

Module CH4

Topic 12	Spectroscopy
Topic 13	Isomerism and Aromaticity
Topic 14	Organic Compounds containing halogens
Topic 15	Organic Compounds containing oxygen
Topic 16	Organic Compounds containing nitrogen
Topic 17	Organic Synthesis and Analysis

Module CH5

Topic 18	Redox
Topic 19	Chemistry of the *s* block
Topic 20	Chemistry of the *p* block
Topic 21	Transition Elements
Topic 22	Periodicity
Topic 23	Chemical Kinetics
Topic 24	Energy changes and Equilibria

CHEMISTRY

1 *INTRODUCTION*

Criteria for Advanced Subsidiary and Advanced GCE

This specification meets the General Criteria for GCE Advanced Subsidiary (AS) and Advanced Level (A) and the Subject Criteria for AS/A Level Chemistry issued by ACCAC/CCEA/QCA (June 1999).

The qualifications will be in accordance with the grading, awarding and certification requirements given in the Code of Practice issued by ACCAC/CCEA/QCA December 2000. Both the Advanced Subsidiary and Advanced GCE qualifications will be reported on a five-grade scale of A, B, C, D and E. Candidates who fail to reach the minimum standard for grade E are recorded as U (unclassified), and do not receive a certificate.

The level of demand of the Advanced Subsidiary examination is that expected of candidates half-way through a full Advanced GCE course. The AS assessment units will have equal weighting with the second half of the qualification (A2) when these are aggregated to produce the Advanced award. The AS and A2 together maintain the standard of the full Advanced GCE qualification.

AS and A2 will each consist of three assessment units, referred to in this specification as CH 1-3 and CH 4-6 respectively. This will allow candidates the opportunity to be assessed either in stages throughout the course, or for all assessments to be taken at the end of the course.

Where a unit has been re-sat, the better results will be used for the qualification award. A candidate may, however, retake the qualification more than once. Individual assessment units, prior to certification for a qualification, have a shelf-life limited only by the shelf-life of the qualification.

Prior Learning

This specification builds upon the Programmes of Study for Science in Key Stages 1-3 and the knowledge, understanding and skills set out in the National Curriculum Key Stage 4 programme of study for Double Award Science.

It is recommended that candidates embarking on the course should have a competence in science equivalent to either that attained at Science: Double Award (Grade C) or with VCE Science: Level 2 (Merit), and a general competence in literacy and numeracy skills.

Progression

The specification is intended to cater for candidates

- continuing with further studies in chemistry,
- requiring a chemical background for study in other subject areas,
- seeking opportunities to develop the Key Skills of communication, application of number, information technology, working with others, improving own learning and performance and problem-solving at level 3 in a chemical scientific context,
- entering directly into employment.

The specification is not age specific and, as such, provides opportunities for candidates to extend their life-long learning.

Overlap with other qualifications and prohibited combinations

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 only have one grade (the highest) counted for the purpose of the School and College Performance Tables.

There is no overlap with other WJEC GCE qualifications nor with Advanced VCE in Science at Unit level. However, there is content in common with the Mandatory and Optional units of Advanced VCE Science.

There are no prohibited combinations of AS/A Chemistry with other WJEC AS/A GCE specifications nor with Advanced VCE(s) in Science.

Language of Specification and Assessment Materials

The specification and specimen papers will be published in English and Welsh. Similarly, the question papers will be available, on request, in both languages.

Candidates with particular requirements

Details of the special arrangements and special consideration for candidates with particular requirements are contained in the Joint Council for General Qualifications document *Candidates with Special Assessment needs*: *Regulations and Guidance.* Copies of this document are available from the WJEC.

2 AIMS

This specification is intended to provide a framework for an AS/A GCE chemistry course which will encourage candidates to:

- develop essential knowledge and understanding of the concepts of chemistry, and the skills needed for the use of these in new and changing situations;
- develop understanding of the link between theory and experiment;
- be aware of how advances in information technology and instrumentation are used in chemistry;
- appreciate the contributions of chemistry to society and the responsible use of scientific knowledge and evidence;
- sustain and develop their enjoyment of, and interest in, chemistry.

In addition the Advanced GCE specification will encourage candidates to:

- bring together knowledge of ways in which different areas of chemistry relate to each other.

Rationale

Chemistry is concerned with the study of materials, how they react, and how the materials can be put to use. Practical work and the theories that arise from experimentation are integral to this study.

The overarching aim of the specification is to promote candidates interest in, and knowledge, understanding and skills of, chemistry and to reflect the significant role played by chemists in the development of a modern 21st century society.

To this end the knowledge, principles and skills, in the Content and Learning Outcomes of Section 3, are permeated with industrial and technological applications of chemistry.

The beneficial role of chemistry to society is illustrated by the usefulness of chemical products such as polyalkenes (Topic 8), polyesters (Topics 15 & 17), polyamides (Topic 16), pharmaceutical products (Topic 17) and chlorine containing compounds (Topics 14 & 20). The industrial contribution made by chemistry in the 20th century is demonstrated by, for example, the petrochemical industry (Topic 8), the Haber and Contact processes (Topic 11), polymer production (Topics 11, 15 & 17). The application of spectroscopic techniques demonstrates the ability of chemists to solve analytic problems in industry, medicine and the environment (Topics 12 & 17).

In addition the specification aims to develop awareness and understanding of environmental and ethical issues, and also health and safety requirements.

The necessity for the responsible use of scientific knowledge and evidence is recognised by the presence in the specification of environmental problems, such as, ozone depletion, the 'greenhouse' effect and acid rain (Topic 11) and the adverse environmental effects of CFCs (Topic 14). The uses and hazards of radioactivity embedded within the specification (Topic 1) contribute to supporting informed debate on health and safety issues and towards informed citizenship.

3 *CONTENT AND LEARNING OBJECTIVES*

Preamble

In this section the approach adopted is to list first all of the topics to be dealt with and then to state the learning outcomes which should follow from them. In so doing the objectives given in Section 7 have throughout been kept in mind and in particular every effort had been made to stress the aims in Section 2. Thus, wherever possible, the social, economic, industrial and technological aspects of chemistry and health and safety issues have been emphasised in the content.

In the learning outcomes many of the terms used such as '*recall*', '*describe*', '*apply*', '*calculat*e', and so on will be self explanatory but in two cases a brief explanation is appropriate.

The word '*appreciate*' is used for important general principles, e.g. Topic 3.2 (d) and (e), usually of wide applicability, the grasp of which should substantially improve chemical understanding.

The term '*show an awareness*' is also used e.g. Topic 1 (h) and 5.2 (g). Here it is expected that the student should be familiar with and be able to explain in outline the point or principle being made, as well as being able to write a short paragraph (with examples of *their* own choice) setting out her/his understanding of the topic. It will not, however, be required that candidates should be able to answer specific detailed questions or problems of the *examiners'* choice, based on that particular learning outcome.

MODULE CH1

TOPIC 1 ATOMIC STRUCTURE

1.1 Fundamental particles: the electron, proton and neutron. The nucleus; atomic number, mass number, isotopes.

Radioactivity: α - and β - particles and γ - radiation; uses and hazards of radioactivity.

1.2 Standard molar ionisation energies of gaseous atoms. Successive ionisation energies and electronic configuration. Electron shells and sub-shells. Atomic orbitals and their shapes; *s, p* and *d*-orbital occupation for elements of atomic number 1-36; electronic ground states of atoms. The Periodic Table.

Learning outcomes **Topic 1**

Candidates should be able to:

(a) describe electrons, protons and neutrons in terms of their relative charges and masses, and the distribution of charges and mass within atoms;

(b) define and explain the terms *atomic number*, *mass number*, *isotope*, and the connection between atomic numbers and mass numbers;

(c) deduce, given atomic and mass numbers, the numbers of protons, neutrons and electrons in specified isotopes;

(d) describe the nature of α - and β - particles and of γ - radiation and recall their behaviour in electric fields and their relative penetrating powers;

(e) describe and explain the changes in mass number and atomic number resulting from α - and β - particle emission;

(f) describe the adverse consequences for living cells of exposure to γ - radiation and to α - and β - emitters;

(g) explain what is meant by the half-life of a radioactive isotope; appreciate that the half-life is inversely proportional to the rate of decay and perform simple calculations involving integral numbers of half-lives;

(h) show an awareness of the importance of radioactive decay and half-life in health and in medicine, radio-dating and analysis;

(i) understand and explain the significance of standard molar ionisation energies of gaseous atoms and their variation from one element to another;

(j) describe and explain how information about the electronic structure of atoms may be deduced from values of successive ionisation energies;

(k) describe the shapes of *s* and *p* orbitals;

(l) recall the appropriate *s*, *p* and *d* orbital occupations for elements 1 - 36 (using 'arrows in boxes' or otherwise) and relate these to position in the Periodic Table.

TOPIC 2 THE MOLE AND STOICHIOMETRY

2.1 Relative atomic, isotopic and molecular masses. Definition of the mole in terms of the ${}^{12}_{6}C$ isotope. Avogadro constant. Empirical and molecular formulae.

2.2 The principle and uses of the mass spectrometer. Mass spectrum of chlorine.

2.3 The quantitative use of the mole concept: calculations involving masses and volumes, and concentrations. Molar volume.

2.4 Symbolic representation of chemical reactions specified in Module CH1, and for reactions of given stoichiometry, in terms of ionic or stoichiometric equations.

Learning outcomes **Topic 2**

Candidates should be able to:

(a) demonstrate their understanding of the terms *relative atomic mass*, *relative isotopic mass*, *relative molecular mass* and *molar mass*, based on the ${}^{12}_{6}C$ scale, and of the Avogadro constant, and define the mole in terms of the ${}^{12}_{6}C$ isotope;

(b) demonstrate understanding of the terms *empirical* and *molecular* formulae and the distinction between them;

(c) explain the principles of the mass spectrometer and understand its uses, including the determination of the relative abundance of isotopes, relative isotopic and relative atomic masses, and describe and explain the mass spectrum of the chlorine molecule;

(d) carry out the interconversion of grams to moles (and vice-versa) for any given species;

(e) understand and use concentration data, expressed in terms of either mass or moles, per unit volume;

(f) calculate the mass of one reagent reacting with a given mass of another or forming a given mass of product(s), given the stoichiometry of the process;

(g) use the molar volume to calculate the number of moles in a given volume of a gas, at a given temperature and pressure, (and vice versa), and to correct such volumes for changes in temperature **or** pressure using Charles's Law ($V \propto T$) **or** Boyle's Law ($V \propto 1/P$), as appropriate;
(*Formal definitions of Boyle's Law and Charles' Law are not required.*)

(h) represent chemical reactions by means of balanced stoichiometric or ionic equations as appropriate.

TOPIC 3 STRUCTURE AND BONDING

3.1 Forces within molecules

3.1.1 Electron transfer and the ionic bond. Electrostatic interactions between ions. Energy changes in the formation of positive and negative ions.

3.1.2 Covalent bonding, including the co-ordinate bond as a special case. Electron sharing and pairing of spins. Electron density distribution for the hydrogen molecule.

3.1.3 Comparison of electron density distribution in covalent and ionic bonds; bond polarity, factors influencing the incidence of ionic or covalent bonding. Covalent and ionic bonds as limiting cases of a continuous range of behaviour. Electronegativity and bond polarity; examples of polar covalent bonds,
($X^{\delta+} – Y^{\delta-}$): C – Cl, H – Cl, C=O, O–H etc.

Learning outcomes **Sub-Topic 3.1**

Candidates should be able to:

(a) describe ionic and covalent bonding (including coordinate bonding) and represent this in terms of appropriate 'dot and cross' diagrams;

(b) relate the appropriate energy changes to the ease or difficulty of the formation of particular cations or anions;

(c) describe qualitatively the nature of the attractive and repulsive forces between ions in an ionic crystal;

(d) show an understanding of the covalent bond in terms of the sharing (and spin pairing) of electrons and show awareness of the forces of attraction and repulsion within the molecule;

(e) sketch and explain the electron density distribution for (i) the hydrogen molecule and (ii) a typical ionic bond;

(f) appreciate that many bonds are intermediate in character between purely ionic and purely covalent and understand the way in which the electron density distribution varies with the ionic character of the bond;

(g) understand and explain the influence of size, formal charge and electronic configuration on whether ionic (or covalent) bonding results;

(h) understand the concepts of electronegativity and of bond polarity, recall that bond polarity is largely determined by differences in electronegativity and use given values to predict such polarities.

3.2 Forces between Molecules

3.2.1 Interactions between molecules, van der Waals' forces (dipole-dipole, induced dipole-induced dipole).

3.2.2 Hydrogen bonding; its occurrence, nature and influence on the physical properties of liquid water and ice.

Learning outcomes **Sub-topic 3.2**

Candidates should be able to:

(a) explain the concept of a dipole and give a simple account of van der Waals' forces (dipole-dipole, induced dipole-induced dipole);

(b) explain the nature of hydrogen bonding and recall the types of elements with which it occurs e.g. with hydrogen attached to highly electronegative atoms;

(c) describe and explain the influence of hydrogen bonding on physical properties in general and specifically in liquid water and ice;

(d) appreciate that forces **within** molecules generally influence their chemical properties, whilst forces **between** molecules usually affect their physical properties;

(e) appreciate the relative orders of magnitude of the strength of: covalent bonds; hydrogen bonds and van der Waals' forces.

3.3 Shapes of Molecules and Ions

3.3.1 Repulsion between electron pairs: lone pairs and bonding pairs. The valence shell electron pair repulsion (VSEPR) principle and its application in determining the shapes of simple molecules and ions: BF_3, CH_4, NH_3, H_2O, SF_6, NH_4^+ and gaseous PCl_5.

3.3.2 Use of the VSEPR principle in the treatment of other simple species with up to six electron pairs in the valence shell.

Learning outcomes **Sub-topic 3.3**

Candidates should be able to:

(a) explain what is meant by the terms *lone pairs* and *bonding pairs* of electrons and recall and explain the sequence of repulsions between: two bonding pairs; a bonding pair and a lone pair; two lone pairs;

(b) explain the VSEPR principle in terms of minimising the total repulsions between electrons in the valence shell of a given molecule or ion, giving examples where appropriate;

(c) recall and explain the shapes of the species listed (recall of exact bond angles is required for BF_3, CH_4, SF_6 and NH_4^+) and apply the VSEPR principle to predict or explain the shapes of other specified simple species involving up to six electron pairs in the valence shell of the central atom.

TOPIC 4 GASES, LIQUIDS AND SOLIDS

4.1 The behaviour of ideal gases.

4.2 Simple kinetic-molecular description of liquids. Vapour pressure of a pure liquid and its temperature dependence.

4.3 Solubility of compounds in water. Hydrates. Simple approach considering hydrogen bonding in water and ability of solutes to displace or interact with water molecules.

4.4 Ionic solids; the crystal structures of sodium chloride and caesium chloride. Giant covalent structures; the structures of diamond and graphite. Simple molecular crystals; a simple treatment of solid iodine I_2. Metallic bonding; the simple 'electron sea' model.

4.5 Relationship between crystal structure and bonding and physical properties.

Learning outcomes **Topic 4**

Candidates should be able to:

(a) explain qualitatively the nature of ideal gases using simple Kinetic Molecular Theory;

(b) use a simple kinetic-molecular model to describe the nature of the liquid state, vaporisation and the variation of vapour pressure with temperature;

(c) use a simple model to explain the ability of certain solutes to dissolve in water either by virtue of hydrogen bonding or dipolar forces and apply this to explain the solubility of ethanol and sodium chloride, and the insolubility (immiscibility) of hydrocarbons, in water;

(d) understand and use solubility both qualitatively and quantitatively (i.e. in terms of mass or moles per unit volume) and understand the recovery of soluble salts from aqueous solution by crystallisation;

(e) recall and describe the crystal structures of sodium chloride and caesium chloride, including the crystal coordination numbers and explain the influence of ionic size;

(f) recall and describe the structures of diamond and graphite and know that iodine forms a molecular crystal;

(g) understand and explain the simple 'electron sea' model for bonding in metals and use it to explain their physical properties;

(h) appreciate and explain the relationship between structure and bonding and physical properties (e.g. hardness, volatility and electrical conductance) for the examples in (e), (f) and (g) above.

TOPIC 5. THE PERIODIC TABLE

5.1 Periodicity

5.1.1 The Periodic Table. Periodic relationships among the elements from H to Ar. Trends across periods: ionisation energies; melting and boiling temperatures; electrical conductivity; electronegativity; atomic and ionic radii; metallic and non-metallic behaviour.

5.1.2 Formulae, bonding and structure of normal oxides and chlorides. Trends in ionic and covalent bonding. The respective basic and acidic properties of metallic and non-metallic oxides. Redox and oxidation state (number).

Learning outcomes **Topic 5.1**

Candidates should be able to:

(a) describe the Periodic Table in terms of the arrangement of elements in groups and periods on the basis of their electronic structure and the classification of elements into *s*, *p* and *d* blocks;

(b) recall the electronic structures of the elements H to Ar and relate these to supplied values and to trends in first ionisation energy, and atomic radii, (atomic radii of He, Ne and Ar not required);

(c) understand the concept of periodicity and its application, and the reasons for the general trends in ionisation energy, melting temperature, boiling temperature, electronegativity, atomic and ionic radii, across periods and down groups;

(d) recall and rationalise the occurrence of elements as metals or non-metals in different parts of the Periodic Table, realise that metallic oxides are generally basic and non-metallic oxides acidic, and appreciate that the oxides of the elements generally become more basic from top to bottom down a group;

(e) predict the general reactivity towards O_2, Cl_2 and H_2O expected of the elements H to Ar;

(f) recall the formulae, bonding and general structural type of the oxides from Na to S and chlorides from Na to P, (i.e. Na_2O, MgO, Al_2O_3, SiO_2, P_4O_{10}, SO_2 and NaCl, $MgCl_2$, Al_2Cl_6, $SiCl_4$ and gaseous PCl_5) and appreciate that oxides and chlorides generally become more ionic from top to bottom down a group;

(g) appreciate and demonstrate understanding of the properties associated with ionic and covalent species in general, with particular reference to chlorides relating specifically to 1. volatility 2. electrical conductivity 3. reaction toward water;

(h) assign oxidation states (numbers) to the atoms in a compound or ion and use these to decide which species have been oxidised and which reduced in a redox reaction;

(i) understand and explain the nature of oxidation and reduction in terms of electron transfer.

5.2 Trends in the properties of elements and compounds within Groups II and VII

5.2.1 Group II (Mg – Ba)
Reactions of the elements with water and dilute acids.
Formulation of the normal oxides and hydroxides and their properties.
Thermal stabilities of the hydroxides and carbonates. Solubilities of the hydroxides and sulphates in water. Reactions of the cations with OH^-, CO_3^{2-} and SO_4^{2-}.
Flame colours of the compounds of Ca, Sr and Ba.
Calcium and magnesium in biology.

5.2.2 Group VII (F – I).
Reactivity and displacement.
The reaction of Cl_2 and Br_2 with water.
Redox as electron transfer: oxidation and reduction as illustrated by simple reactions of the halogens.
Halide ions (Cl^-, Br^- and I^-) with Ag^+(aq) followed by aqueous NH_3.

Learning outcomes **Topic 5.2**

Candidates should be able to:

(a) recall the typical behaviour of the elements of Group II with O_2, Cl_2, H_2O and dilute acids (*excluding nitric acid*) and the trend in their general reactivity †;

(b) describe the reactions of the aqueous cations, Mg^{2+}, Ca^{2+} and Ba^{2+} with OH^-, CO_3^{2-} and SO_4^{2-} †;

(c) recall the formulae of the oxides (MO) and hydroxides ($M(OH)_2$) of Group II and describe the nature of the oxides MgO, CaO and BaO, and their reactions with water and dilute acids †;

(d) recall the basic nature of the hydroxides of Mg, Ca and Ba and the trends in the solubilities in water of both the hydroxides and the sulphates of those elements and recall the trends in the thermal stabilities of the hydroxides and carbonates of Mg, Ca and Ba †;

[*No theoretical explanation required*.]

(e) recall the flame colours shown by compounds of Ca, Sr and Ba (and that Mg compounds show no colour) and describe their use in qualitative analysis;

(f) recall the interaction of carbon dioxide with water, the formation of hydrogencarbonate HCO_3^- and carbonate CO_3^{2-} ions and their interaction with calcium (Ca^{2+}) ions, and understand the importance of these in connection with the hardness of water;

(g) show an awareness of the importance of calcium carbonate and phosphate minerals as skeletons for living systems and the consequent formation of carbonate rocks and the importance of calcium and magnesium in biochemistry;

(h) appreciate and understand the chemistry of the *s*-block as mainly exemplifying typical ionic behaviour;

(i) recall the trend in volatility shown by the elements Cl, Br and I and relate to chemical bonding;

(j) recall and explain the tendency of the halogens (F – I) to react by forming anions (F^-, Cl^-, Br^-, I^-), and recollect that this reactivity decreases on descent of the group *;

(k) recall the general types of reactions undergone by the halogens, including displacement reactions, and explain the group trends and displacements in terms of the position in the Periodic Table and relative oxidising power †*;

(l) describe and understand redox in terms of electron transfer, and apply this insight to displacement reactions of Cl_2 and Br_2 as oxidising agents in their interactions with water †*;

(m) explain the group trends and displacements in terms of position in the Periodic Table;

(n) recall the nature of the reaction between aqueous Ag^+ and halide (Cl^-, Br^-, I^-) ions* followed by aqueous NH_3, and understand the analytical importance of these reactions in qualitative analysis *(ionic equations required for precipitation reactions only)*;

Note:
† Balanced chemical equations are required.
* Ion / electron half equations are required.

MODULE CH2

TOPIC 6. PRINCIPLES OF ENERGETICS

6.1 Principle of conservation of energy. Hess's Law.

6.2 Enthalpy changes of a reaction and of changes of state. Standard molar enthalpy change of formation, $\Delta H_f^{\ominus}$. Bond enthalpies (energies).

Learning outcomes **Topic 6**

Candidates should be able to:

(a) appreciate the principle of conservation of energy and construct simple energy cycles;

(b) understand that chemical reactions are accompanied by energy changes, frequently in the form of heat, and that these may be either exothermic or endothermic and depend partly on the physical states of reactants and products;

(c) understand the term enthalpy change of reaction and the specific terms enthalpy change of combustion, neutralisation and solution (formal definitions are not required);

(d) recall details of experimental procedures for determining enthalpy changes in aqueous solution, and calculate such enthalpy changes from experimental data using

$$\Delta H = mC\Delta Ts$$

where m and C are the mass and specific heat capacity of, for example, the water used, ΔT is the incremental change in temperature, and s is a scaling factor to convert to molar quantities (candidates should understand the precautions needed to obtain precise results);

(e) define standard conditions and the term standard molar enthalpy change of formation, $\Delta H_f^{\ominus}$;

(f) state Hess's Law and use it to calculate enthalpy changes indirectly from energy cycles;

(g) appreciate that the exothermicity or endothermicity of $\Delta H_f^{\ominus}$ may be used as a qualitative indication of the stability of the compound in question and the ease or difficulty of extraction of a given metal from its ores;

(h) understand the concept of average bond enthalpy (energy) and use Hess's Law to carry out simple calculations involving such quantities.

TOPIC 7. ORGANIC COMPOUNDS : NOMENCLATURE; ISOMERISM; REACTION TYPES AND FUNCTIONAL GROUPS

7.1 The nature of functional groups, exemplified (in this Module) by alkanes, alkenes, halogenoalkanes, primary alcohols and carboxylic acids. Homologous series. Nomenclature.

7.2 Structural isomerism. Geometrical isomerism.

7.3 The classification of reaction types.

7.4 The recognition of some functional groups by characteristic chemical reactions.

Learning outcomes **Topic 7**

Candidates should be able to:

(a) write graphic and shortened structural formulae of simple organic compounds as specified in 7.1 given their systematic names, and vice versa;

(b) describe the effect of increasing hydrocarbon chain length and of the above functional groups on physical properties, melting and boiling temperature and solubility;

(c) describe structural isomerism and be able to write down the structural isomers of non-cyclic organic compounds (up to and including C_5 homologues) including those of different chemical class;

(d) describe geometric (*cis/trans*) isomerism in alkenes, give an example, and discuss such isomerism in terms of restricted rotation about the $C=C$ bond, and appreciate that geometric isomers may have different physical and chemical properties;

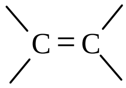
(e) derive empirical formulae from elemental composition data and use such results, together with additional stoichiometric data, to deduce molecular formulae;

(f) identify reactants as electrophilic, nucleophilic or radical in type, explain the basis of this classification, and give examples of each;

(g) classify the following types of functional group reactions and describe their nature: electrophilic addition (e.g. Br_2 to alkenes (7(i), 8(f)), free radical e.g. chlorination of hydrocarbons (8(d)), elimination e.g. of HBr from bromoalkanes (8(g)), oxidation/ reduction e.g. of primary alcohols (7(h)), hydrolysis e.g. of bromoalkanes (7(i)) (also a nucleophilic substitution);

(h) describe the total oxidation of primary alcohols, RCH_2OH, to carboxylic acids, RCOOH. (*Knowledge of the properties of aldehydes is not, at this stage, required*);

(i) recognise the following functional group tests by the indicated reactions:

	(i) addition of Br_2(aq); (ii) reaction with aqueous Mn^{VII}
– X (Cl, Br, I)	hydrolysis by aqueous base, followed by reaction with $AgNO_3$(aq) / HNO_3(aq);
– COOH	addition of Na_2CO_3/$NaHCO_3$ followed by recognition of CO_2 evolved.

TOPIC 8 HYDROCARBONS AND PETROLEUM

8.1 Alkanes : structure; cracking; combustion; chlorination; homolytic and heterolytic bond fission; reactivity and bond enthalpy (energy).

8.2 Alkenes: structure; electrophilic addition, Br_2, HBr, H_2O; catalytic hydrogenation.

8.3 The petrochemicals industry; petroleum; cracking; fuels; polymerisation of alkenes; other products.

Learning outcomes **Topic 8**

Candidates should be able to:

(a) understand and explain the meaning of the terms homolytic and heterolytic bond fission and appreciate the relationship between bond polarity and reactivity;

(b) recall the structures of alkanes and that they are unreactive, that reaction is brought about by homolysis of the strong C – C bond followed by radical attack, and appreciate the connection between reactivity and bond enthalpy;

(c) describe a typical cracking reaction;

(d) (i) describe the photochlorination of methane †;
(ii) recall the mechanism of the reaction as far as CH_2Cl_2 and be aware that the reaction may proceed to CCl_4;

(e) show awareness of the great economic importance of alkane combustion;

(f) describe the structure of and bonding in ethene, classify the addition reactions of Br_2 and HBr (involving heterolytic fission), with ethene and propene, and relate the orientation of the normal addition of HBr to propene to the recalled mechanism of the reaction and the relative stabilities of the possible carbocations (carbonium ions) involved;

(g) recall the addition reaction of ethene with H_2O, the catalytic hydrogenation (reduction) of alkenes, and the preparation of ethene by elimination of HBr from bromoethane †;

(h) describe in outline the general nature of petroleum, its separation into useful fractions by fractional distillation, and the cracking process;

(i) understand the nature of alkene polymerisation and show an awareness of the wide range of important polymers of alkenes and substituted alkenes.

Note:
† Balanced chemical equations are required.

TOPIC 9 PRINCIPLES OF CHEMICAL AND ACID-BASE EQUILIBRIA

9.1 Chemical equilibria; reversible reactions; dynamic equilibrium.

9.2 Factors governing equilibrium: temperature, pressure or concentration.
Le Chatelier's principle.

9.3 Strong and weak acids and bases. pH as a measure of [H^+(aq)]. Dissociation constants, K_a for acids. Acid-base titrations. The ionic product of water, K_w.

Learning outcomes **Topic 9**

Candidates should be able to:

(a) demonstrate their understanding of reversible reactions and dynamic equilibrium;

(b) recall and understand Le Chatelier's principle and apply it qualitatively to deduce the effects of changes in temperature and in pressure or concentration, on a system at equilibrium;

(c) deduce expressions for the equilibrium constants, K_p and K_c in terms of partial pressures or of concentrations, as appropriate;

(d) appreciate that K_p or K_c are constant for a given system at any fixed temperature;

(e) understand the nature of acids as donors of H^+(aq) and bases as acceptors of H^+(aq) and apply this to their behaviour in aqueous solution;

(f) appreciate the utility of the pH scale;

(g) understand and appreciate the distinction between the terms concentrated/dilute and strong/weak and explain qualitatively the differences in behaviour between strong and weak acids and bases, using K_a conceptually;

(h) use the concept of the mole in calculations involving acid - base titration data;

(i) appreciate the significance of the ionic product of water, K_w, and understand that neutralisation involves: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$.

TOPIC 10 CHEMICAL KINETICS

10.1 Factors affecting rates: concentration/pressure; temperature; light. Catalysts as providers of faster reaction rates.

10.2 Qualitative collision theory.

10.3 Energy profiles and distribution. Activation energy.

Learning outcomes **Topic 10**

Candidates should be able to:

(a) name the factors affecting reaction rates, including light in some cases;

(b) outline a method of measuring the rate of a given reaction, explaining the principles involved;

(c) calculate initial rates from initial concentrations and times e.g. from iodine clock reactions such as $2H^+(aq) + 2I^-(aq) + H_2O_2(l) \rightarrow I_2(aq) + 2H_2O(l)$ and understand how such results can elucidate the relationship between rates and reactant concentrations;

(d) describe simple collision theory and qualitatively explain the effects of changes in concentration (or pressure) and temperature on rate by means of this theory;

(e) define activation energy, describe the concept of energy profiles and transition states, and recall that $\Delta H = E_f - E_b$;

(f) explain the rapid increase in rate with temperature in terms of changes in the energy distribution curve;

(g) recall the function of a catalyst and understand that at any temperature the presence of a catalyst:

(i) provides an alternative faster reaction pathway and thus increases the rate of both the forward and back reactions, normally by lowering the activation energy (lower energy profile);
(ii) does not affect the position of equilibrium;
(iii) does affect the time taken to reach equilibrium;

(h) recall that catalysts may be homogeneous or heterogeneous and be able to give one example of each type;

(i) appreciate the distinction between what may be deduced from **equilibrium** data and what may be deduced from **kinetic** data.

TOPIC 11 INDUSTRIAL AND ENVIRONMENTAL ASPECTS

11.1 Technical and economic factors in the siting and operation of industrial processes.

11.2 **Outline** chemistry of some important exemplary processes: Haber process, Contact process, the addition (chain) polymerisation of ethene.

NB *Detailed knowledge of processes is* ***not*** *required. Questions may be set on other processes where basic principles are involved, but in these cases all essential details will be given.*

11.3 Environmental problems and their solution.
Ozone depletion, the 'greenhouse effect', acid rain.

11.4 The beneficial role of chemistry to society and in the environment.

Learning outcomes **Topic 11**

Candidates should be able to:

(a) show an awareness of and discuss the technical and economic factors listed below:

plant costs, raw materials, fuel and energy costs, coolant, transport, markets, local population, waste disposal, environmental damage and safety precautions;

(b) understand and appreciate the importance of reaction rates and chemical equilibria in industrial processes and give one example of this;

(c) explain the reasons for the widespread use of catalysts in industry;

(d) show an awareness that enzymes are powerful catalysts in living systems and that they are increasingly used in industry and everyday life;

(e) recall the **outline** chemistry of the processes listed in 11.2 as rehearsed below;

<u>OUTLINE CHEMISTRY</u>

<u>Haber Process</u>

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

N_2 (from air) and H_2 (from natural gas) are reacted in stoichiometric ratio at 200 atm pressure and 400 °C over an iron catalyst. The reaction is exothermic and yields are 15% per pass.

<u>Contact Process</u>

$$S + O_2 \rightarrow SO_2$$

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

$$SO_3 + H_2O \rightarrow H_2SO_4$$

Sulphur is burnt in air; SO_2 is reacted with excess air over a V_2O_5 catalyst at 420 °C at pressures not much above atmospheric to give over 95% conversion. SO_3 is absorbed in H_2SO_4 rather than H_2O.

<u>Addition Polymerisation (example) – Low density poly(ethene)</u>

$$nCH_2 = CH_2 \rightarrow -\!\!\left(CH_2 - CH_2\right)\!\!-_n$$

is exothermic. Ethene is polymerised at high pressure (2000 atm) and moderate temperature (250°C) using a trace of O_2 or peroxide as a radical chain initiator, and giving a chain of some 10 000 ethene units.

(f) evaluate, where appropriate, the effect of physico-chemical principles related to rate and yield on the individual processes listed in 11.2;

(g) use supplied information to interpret the **outline** chemistry associated with ozone depletion, the 'greenhouse effect' and acid rain and show understanding of these problems and of the steps which need to be taken to counteract them;

(h) show an appreciation of the importance, with regard to these problems, of the interaction between radiation (sunlight) and matter;

(i) suggest alternative energy sources to the combustion of alkanes and discuss their feasibility in outline;

(j) show an awareness, and give examples of, the important role of the chemist in solving the problems (in (f) above) and of the positive chemical contributions in, for example, drug design, anaesthetics, agriculture, semiconductor technology;

(k) discuss the social and moral implications of the use of chemical discoveries and inventions and the responsible use of scientific knowledge and evidence.

MODULE CH4

TOPIC 12 SPECTROSCOPY

12.1 The electromagnetic spectrum; frequencies; wavelengths; energies of radiation involved in ultraviolet (u.v.)-visible and in infrared (i.r.) spectra; transitions between available energy levels; emission and absorption spectra.

12.2 Atomic spectra - the hydrogen atom spectrum.

12.3 Origin of colour; chromophores in organic systems (electronic spectra).

12.4 The uses of ultraviolet-visible, infrared and nuclear magnetic resonance spectra in organic chemistry.

Learning Outcomes **Topic 12**

Candidates should be able to:

(a) recall the energy gradation across the electromagnetic spectrum from u.v. to visible to i.r. spectra;

(b) appreciate the quantisation of energy;

(c) understand the existence of various available energy levels in atomic and molecular systems, restricted to electronic and vibrational levels;

(d) explain the origin of emission and absorption spectra;

(e) appreciate that energy levels can be split by a magnetic field, that certain nuclei, including ^{1}H, possess intrinsic spin, and that measurements of the magnitudes of the interactions between the nuclear spin and the magnetic field are the basis of nuclear magnetic resonance spectroscopy;
(*The required understanding of n.m.r. spectroscopy is limited to the above and that in Topic 17, outcome(d).*)

(f) describe and interpret the visible atomic spectrum of the hydrogen atom (Balmer Series);

(g) recall the direct proportionality between energy and frequency, as implied by $E = hf$, and the inverse relationship between frequency and wavelength;

(*No calculations will be set.*)

(h) show understanding of the relationship between the frequency of the convergence limit of the Lyman Series and the ionisation energy of the hydrogen atom;

(i) explain why some substances are coloured in terms of the wavelengths of visible light absorbed;

(j) explain the nature of a chromophore and give examples of such groups in organic species, e.g. –N = N– in azo dyes;

(k) use **given** characteristic i.r. vibrational frequencies (expressed in cm^{-1}), to identify simple groupings in organic molecules;

(l) show understanding of the wide applicability of spectroscopic techniques to analytical problems in industry, medicine and the environment.

TOPIC 13 ISOMERISM AND AROMATICITY

13.1 Nomenclature.

13.2 Stereoisomerism - geometrical, optical.

13.3 Benzene: delocalisation energy of benzene; structure and reactivity; electrophilic nuclear substitution; explanation in terms of π electron delocalisation; comparison with alkenes.

Learning Outcomes **Topic 13**

Candidates should be able to:

(a) give the systematic names of all simple compounds, including benzene derivatives, containing the functional groups occurring in this Module;

(b) understand the term stereoisomerism as embracing both geometrical and optical isomerism;

(c) explain what is meant by a chiral centre, recall that this gives rise to optical isomerism, and be able to identify chiral centres in given molecules, and understand what is meant by an enantiomer;

(d) recall that enantiomers rotate plane-polarised light in opposite directions and that equimolar amounts of enantiomers form racemic mixtures;

(e) calculate the delocalisation or resonance energy of benzene from given enthalpy data;

(f) describe the structure of, and bonding in, benzene;

(g) describe and classify the nitration and halogenation reactions of benzene as electrophilic substitution, and recall the mechanism of the mono-nitration of benzene *;

(h) compare benzene and alkenes with respect to benzene's resistance to addition and explain this resistance in terms of π electron delocalisation.

Note:
* Conditions required.

TOPIC 14 ORGANIC COMPOUNDS CONTAINING HALOGENS

14.1 Formation of halogenoalkanes by direct halogenation of alkanes.

14.2 Nucleophilic substitution of halogenoalkanes by OH^-, CN^- and NH_3. Mechanism of alkaline hydrolysis.

14.3 Comparative alkaline hydrolysis of 1-chlorobutane and chlorobenzene.

14.4 Industrial, commercial and medical uses. Solvents. Refrigerants (CFCs). Anaesthetics. Toxicity. Adverse environmental effects of CFCs.

Learning outcomes **Topic 14**

Candidates should be able to:

(a) describe the formation of a chloroalkane by direct chlorination of alkanes †*;

(b) (i) describe the substitution reaction with OH^- and explain this on the basis of the recalled mechanism of the alkaline hydrolysis of 1-bromobutane †*;

(ii) describe the substitution reactions with CN^- and NH_3 † *;

(c) compare the ease of alkaline hydrolysis of chloroalkanes and chlorobenzene and explain the difference in terms of the C – Cl bond strength, and rationalise the greater strength of the C – C1 bond in the latter case;

(d) show an awareness of the wide use of halogenoalkanes as solvents, the toxicity of some of them, the use of CFCs as refrigerants and in aerosols, and their use in anaesthetics as well as the adverse environmental effects of CFCs;

(e) understand the adverse environmental effects of CFCs and explain these in terms of the relative bond strengths of the C – H, C – F, and C – C1 bonds involved (c.f. 11(g));

(f) show an awareness of the use of organohalogen compounds as pesticides and polymers and assess their environmental impact.

Note:
† Balanced chemical equations are required.
* Conditions required.

TOPIC 15 ORGANIC COMPOUNDS CONTAINING OXYGEN

15.1 Alcohols and phenol

15.1.1 Physical properties of alcohols.

15.1.2 Formation of primary and secondary alcohols by hydrolysis and reduction.

15.1.3 Formation of alcohols by addition.

15.1.4 Oxidation, dehydration and other reactions of alcohols.

15.1.5 Ethanol in a social context.

15.1.6 Acidity and reactions of phenol.

Learning outcomes **Sub-topic 15.1**

Candidates should be able to:

(a) describe the physical properties of the lower alcohols, solubility in water and relatively low volatility, and relate this to the existence of hydrogen bonding;

(b) describe the methods of forming primary and secondary alcohols from halogenoalkanes and carbonyl compounds *;

(c) recall a method for the industrial preparation of ethanol from ethene;

(d) recall:
  (i) the reactions of primary and secondary alcohols with hydrogen bromide, ethanoyl chloride and carboxylic acids (to give sweet smelling esters) †;
  (ii) the dehydration reaction (elimination) of primary alcohols †;

(e) describe the oxidation reactions of primary (7(g)) and secondary alcohols;

(f) show awareness of the importance of ethanol-containing drinks in society, their ethanol content, breathalysers, and the effects of ethanol excess;

(g) show an awareness of the use of ethanol as a fuel;

(h) explain the acidity of phenol and describe its reactions with bromine and with ethanoyl chloride;

(i) recall the colour reaction of some phenols with $FeCl_3$ solution and the use of this test to distinguish phenols from alcohols.

Note:
† Balanced chemical equations are required.
* Conditions required.

15.2 Aldehydes and ketones

15.2.1 Formation from alcohols.

15.2.2 Relative ease of oxidation of aldehydes. Tollens' reagent. Fehling's reagent.

15.2.3 Reduction using $NaBH_4$.

15.2.4 Nucleophilic additions.

15.2.5 Triiodomethane (Iodoform) reaction.

Learning outcomes **Sub-topic 15.2**

Candidates should be able to:

(a) describe the formation of aldehydes and ketones by the oxidation of primary and secondary alcohols respectively (cf Topic 15.1);

(b) describe how aldehydes and ketones may be distinguished by their relative ease of oxidation using Tollens' reagent and Fehling's reagent †*;

(c) recall the use of $NaBH_4$ to reduce aldehydes and ketones and the products formed thereby *;

(d) describe the reaction of aldehydes and ketones with 2,4-dinitrophenylhydrazine reagent as a nucleophilic addition-elimination (condensation) reaction and explain the use of this reaction in showing the presence of a carbonyl group and in identifying specific aldehydes and ketones by determining the melting temperatures of the purified products;

(e) describe and understand the mechanism of the addition of HCN to carbonyl compounds as an example of a nucleophilic addition reaction;

(f) describe how the triiodomethane (iodoform) test is carried out and explain its use in detecting CH_3CO – groups or their precursors (cf Topic 15.1).

Note:
† Balanced chemical equations are required.
* Conditions required.

15.3 Carboxylic acids and their derivatives

15.3.1 Physical properties and comparative acidity of carboxylic acids.

15.3.2 Formation of carboxylic acids from alcohols and aldehydes.

15.3.3 Conversion to esters and acid chlorides, and the hydrolyses of these compounds.

15.3.4 Reduction of acids using $LiAlH_4$; decarboxylation of acids.

15.3.5 Industrial importance of ethanoic anhydride and polyesters.

Learning outcomes **Sub-topic 15.3**

Candidates should be able to:

(a)

- (i) describe the physical properties of lower carboxylic acids (volatility and solubility) and relate these to the presence of hydrogen bonding;
- (ii) discuss and show understanding of the relative acidities of carboxylic acids, phenol, alcohols and water, and appreciate that carboxylic acids liberate CO_2 from carbonates and hydrogencarbonates but that phenol does not;
- (iii) recall that phenols in aqueous solution give colour reactions with iron(III) chloride solution;

(b) recall the following listed processes and apply knowledge of them to the elucidation of organic problems:

- (i) the formation of carboxylic acids from alcohols and aldehydes *;
- (ii) the formation of aromatic carboxylic acids by the oxidation of methyl side-chains with alkaline Mn^{VII} and subsequent acidification*;
- (iii) methods of converting the acids to esters and acid chlorides, and the hydrolyses of these compounds †*;
- (iv) the behaviour of acids on reduction with $LiAlH_4$; acid decarboxylation and its use in structure determination *;

(c) recall the industrial importance of ethanoic anhydride and polyesters.

Note:
† Balanced chemical equations are required.
* Conditions required.

TOPIC 16 ORGANIC COMPOUNDS CONTAINING NITROGEN

16.1 Primary amines and amino acids

16.1.1 Formation of primary aliphatic and aromatic amines.

16.1.2 Amines as bases. Ethanoylation using ethanoyl chloride.

16.1.3 Comparative reactions of primary aliphatic and aromatic amines with nitric(III) acid (nitrous acid), HNO_2. Coupling of diazonium salts with phenols, e.g. naphthalen-2-o1 and aromatic amines. Azo dyes.

16.1.4 Formulae, structure and amphoteric nature of α-amino acids.

16.1.5 Dipeptides. Outline of protein structure.

16.1.6 Biological aspects. Enzymes.

Learning outcomes **Sub-topic 16.1**

Candidates should be able to:

(a) describe the preparation of primary aliphatic and aromatic amines from halogenoalkanes and nitrobenzenes respectively;

(b) recall that, and explain why, amines are basic;

(c) recall the ethanoylation reaction of primary amines using ethanoyl chloride †;

(d) compare the reaction of primary aliphatic and aromatic amines with cold nitric(III) acid (nitrous acid), describe the coupling of benzenediazonium salts with phenols such as naphthalen-2-o1 and aromatic amines and the importance of this reaction for azo dyes; recall the role of the –N=N– chromophore in azo dyes and be aware that this group links two aromatic rings (cf Topic 12);

(e) recall the general formulae of α-amino acids and discuss their amphoteric and zwitterionic nature;

(f) write down the possible dipeptides formed from two different α-amino acids;

(g) understand the formation of polypeptides and proteins and have an outline understanding of protein structure;

(h) show an awareness of the importance of proteins in living systems, e.g. as enzymes.

Note:
† Balanced chemical equations are required.

16.2 Amides and nitriles

16.2.1 Conversion of acids to amides and the hydrolysis of amides.

16.2.2 Reduction of nitriles using $LiAlH_4$, and the hydrolysis of nitriles.

16.2.3 Industrial importance of polyamides.

Learning outcomes **Sub-topic 16.2**

Candidates should be able to:

(a) recall the following listed processes and apply knowledge of them to the elucidation of organic problems:

(i) methods of converting carboxylic acids to amides;
(ii) the reduction of nitriles with $LiAlH_4$ and the hydrolysis of nitriles and amides;

(b) recall in outline the mode of: the synthesis and the industrial importance of polyamides and understand the similarity of the $-\overset{\overset{\displaystyle H}{|}}{N}-\underset{\underset{\displaystyle O}{||}}{C}-$ linkage therein to that in naturally occurring proteins.

TOPIC 17 ORGANIC SYNTHESIS AND ANALYSIS

17.1 Calculation of empirical formulae from elemental compositions and derivation of molecular formulae.

17.2 Use of simple mass spectral fragmentation patterns in structure elucidation.

17.3 Use of characteristic infrared frequencies (vibrational spectra) in structure elucidation.

17.4 Use of characteristic n.m.r. shifts and splitting patterns.

17.5 Combination of reactions named in the syllabus to carry out organic conversions.

17.6 Yields in preparative processes.

17.7 Practical techniques - Safe procedures.

17.8 Syntheses of industrial and pharmaceutical importance.

Learning outcomes **Topic 17**

Candidates should be able to:

(a) derive empirical formulae from elemental composition data and deduce molecular formulae from these results plus additional data such as titration values, gas volumes, mass spectrometric molecular ion values and gravimetric results;

(b) use given mass spectral data to elucidate the structure of simple non-cyclic organic molecules (up to and including C_5 molecules, with one chlorine atom) (cf Topic 2.2.);

(c) interpret given simple infrared spectra using characteristic group frequencies (supplied in cm^{-1}) : O–H (str), N–H (str), C≡N (str), C = O (str) and N–H (bend) [str = stretch];

(d) understand that n.m.r. spectra can give information regarding the environment and number of equivalent hydrogen atoms in organic molecules and use such supplied information in structure elucidation *;

* *Candidates will be supplied with simplified n.m.r. spectra of relevant compounds and with a table listing the approximate positions of commonly encountered resonances. They will also be supplied with an indication of the relative peak areas of each resonance and with a note that the splitting of any resonance into n components indicates the presence of n-1 hydrogen atoms on the* ***adjacent*** *carbon, nitrogen or oxygen atoms.*

(e) outline the general reaction conditions and basic techniques of manipulation, separation and purification used in organic chemistry, and recall the essential safety requirements during these operations;

(f) propose sequential organic conversions by combining a maximum of three reactions in the syllabus;

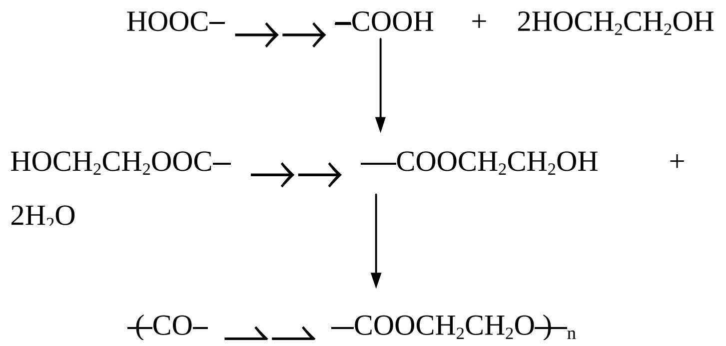
(g) deduce percentage yields in preparative processes;

(h) show understanding of the wide applicability of spectroscopic techniques to analytical problems in industry, medicine and the environment;

(i) understand and be able to explain and exemplify the distinction between condensation polymerisation and addition polymerisation (Topic 8, l.o.(i));

(j) recall, as examples of important industrial and pharmaceutical processes, the outline chemistry of the manufacture of polyesters, polyamides and aspirin as rehearsed below:

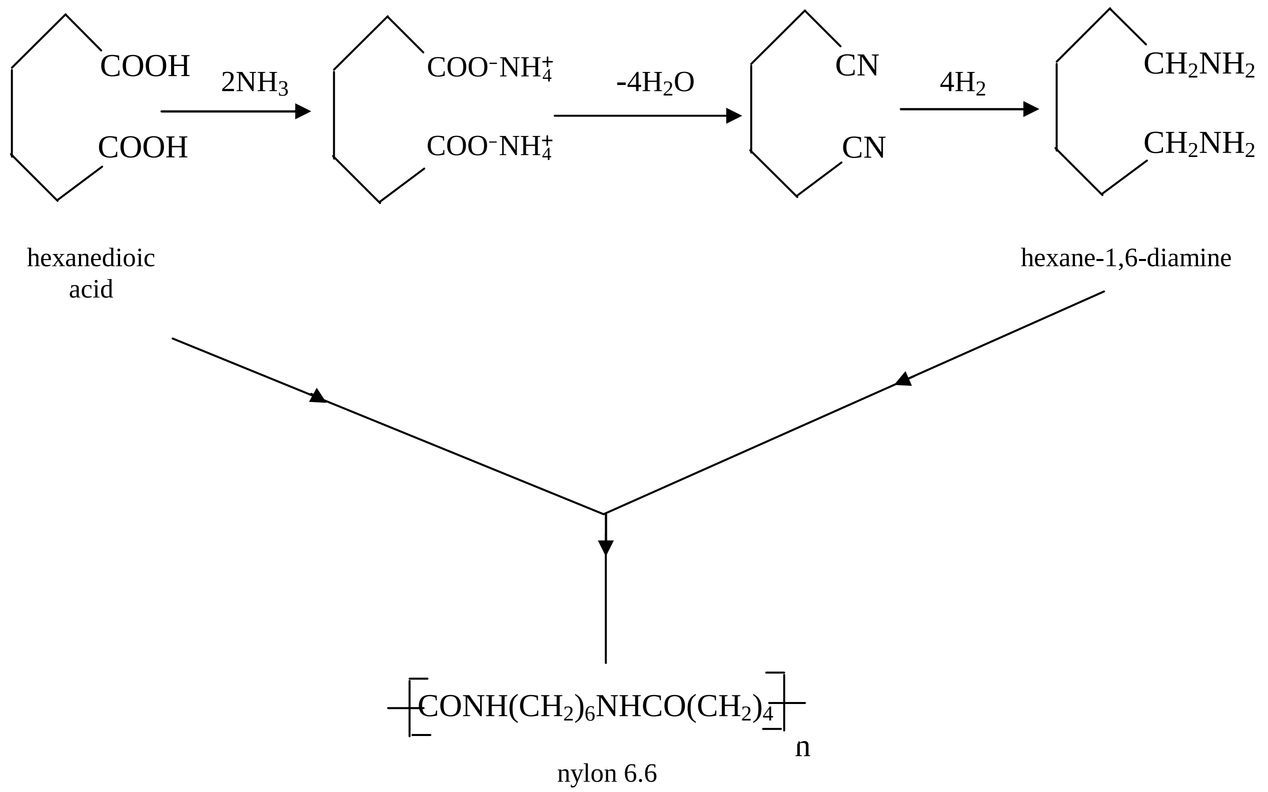
<u>Condensation Polymerisation (example) – polyesters</u>



The process is carried out at relatively low pressure and 260 °C.

Polyesters are formed from carboxylic acids and alcohols which both possess two functional groups.

<u>Condensation Polymerisation (example) - polyamide</u>



Polyamides are formed from carboxylic acids and amines which both possess two functional groups.

Pharmaceutical Process (example) —— Aspirin

Sodium phenate (from phenol and NaOH) is reacted with CO_2 under pressure at 100 °C and the product acidified to give 2-hydroxybenzenecarboxylic acid (salicylic acid). This is treated with ethanoic anhydride at 90 °C to give ethanoyloxybenzenecarboxylic acid (aspirin).

MODULE CH5

TOPIC 18 REDOX

18.1 Redox. Electron transfer: oxidation and reduction. Oxidation state.

18.2 Ion /electron half equations.

18.3 Electrode systems exemplified by: $Cu^{2+}(aq)|Cu(s)$; $Zn^{2+}(aq)|Zn(s)$; $H^{+}(aq)|H_2(g)\ Pt$; $Fe^{3+}(aq), Fe^{2+}(aq)|Pt$; $MnO_4^-(aq), Mn^{2+}(aq)|Pt$; $X_2(g)|2X^-(aq)$. ($X = Cl^-, Br^-, I^-$).

18.4 Redox reactions and electrode potentials. Cells. Standard electrode potentials, $E^{\ominus}$; their use to predict feasibility of specified reactions. Metal extraction.

18.5 Redox reactions exemplified by $Cr_2O_7^{2-}$ with Fe^{2+}; MnO_4^- with Fe^{2+}; I_2 with $S_2O_3^{2-}$ and its use to determine Cu^{2+}; and the associated titrations.

Learning outcomes **Topic 18**

Candidates should be able to:

(a) describe redox in terms of electron transfer, use oxidation states (numbers) to decide which species have been oxidised and which reduced in a redox reaction;

(b) write ion-electron half equations for redox reactions for which stoichiometric information is supplied, and use titration and other data to carry out appropriate calculations;

(c) recall and use the redox reactions specified in 18.3 and 18.5 above, including the appropriate colour change and ion/electron half-equations, and use titration and other data to carry out calculations;

(d) describe the use of $Cr_2O_7^{2-}$ as an oxidising agent, including the appropriate ion/electron half equation for the $Cr_2O_7^{2-} \rightarrow Cr^{3+}$ conversion, the interconversion reaction of $Cr_2O_7^{2-} \rightleftharpoons CrO_4^{2-}$ and recall the colours of all the above listed species;

(e) describe the redox reaction between Cu^{2+} and I^- and the determination of the liberated iodine with $S_2O_3^{2-}$,

(f) appreciate the very wide range of occurrences of redox processes in chemistry;

(g) describe simple electrochemical cells involving
(i) metal/metal ion electrodes, and
(ii) electrodes based on different oxidation states of the same element;

(h) explain and use the term standard electrode potential especially
(i) the use of the standard hydrogen electrode in 18.3 in determining standard electrode potentials,
(ii) to calculate standard potentials of cells formed by combining different electrodes and
(iii) to predict the feasibility of specified reactions;

(i) show awareness that electrode processes represent oxidations and reductions.

TOPIC 19 CHEMISTRY OF THE *S*-BLOCK: GROUPS I AND II

19.1 Trends in the *s*-block: reactions of the elements (Li - Cs) with water, their normal oxides and hydroxides. Flame tests.

19.2 Salient differences between the behaviour of Group I compounds and Group II compounds.

Learning outcomes **Topic 19**

Candidates should be able to:

(a) recall the reactions of the elements (Li – Cs) with water and explain the trends in their general reactivity †;

(b) recall for Group I elements the formulae of the oxides (M_2O) and the hydroxides (MOH) and the reactions of the oxides with water †;

(c) recall the flame colours of the elements Li, Na and K and their use in qualitative analysis;

(d) appreciate and understand the chemistry of the *s* - block as mainly exemplifying typical ionic behaviour and draw comparisons between the behaviour of Group I compounds and those of Group II as exemplified by

- (i) the much greater solubility in water of most Group I compounds,
- (ii) the differences in the mode of thermal decomposition of the nitrate(V) salts,
- (iii) the generally higher stabilities of the hydrogencarbonates of Group I.

(e) recall the formation and chemical properties of the saline hydrides of Groups I and II.

Note:
† Balanced chemical equations required.

TOPIC 20 CHEMISTRY OF THE *P*-BLOCK

20.1 Group IV (C-Pb)

20.1.1 Changes in the nature of the element down the group.

20.1.2 The inert pair ion effect in Groups III, IV and V. Relative stability of oxidation states II and IV in Group IV.

20.1.3 Oxides and chlorides of C, Si and Pb.

20.1.4 Reactions of Pb^{2+}.

Learning outcome **Sub-topic 20.1**

Candidates should be able to:

(a) describe the change from non-metallic to metallic elements down the group;

(b) show knowledge of the increasing stability of the inert pair (ns^2) cations on descent of Groups III, IV and V;

(c) describe the change in relative stability of oxidation states II and IV down Group IV, the reducing properties of Sn^{2+}(aq) and the oxidising nature of Pb(IV), e.g. the reaction with concentrated hydrochloric acid †;

(d) recall the nature, physical, acid-base and redox properties of the oxides of C and Pb (CO, CO_2, PbO and PbO_2) the reducing properties of CO and the oxidising properties of PbO_2 †;

(e) describe the types of bonding in the chlorides of C, Si and Pb and their reactions with water †;

(f) recall the reactions of Pb^{2+}(aq) with NaOH, Cl^-, I^- and SO_4^{2-} †.

Note:
† Balanced chemical equations required.

20.2 Group VII (Cl, Br and I only)

20.2.1 Group trends and displacement reactions.

20.2.2 Reaction of sodium halides with concentrated H_2SO_4.

20.2.3 Oxidation states of the halogens in oxyacids and their anions. Reaction of Cl_2 with NaOH(aq).

20.2.4 Halogen compounds in commerce and industry.

Learning outcomes **Sub-topic 20.2**

Candidates should be able to:

(a) explain the group trends and displacements in terms of position in the Periodic Table and $E^{\ominus}$ values;

(b) recall the existence of C1 and I in oxidation states -I, +I and +V (and the formulae $C1O^-$, $C1O_3^-$ and IO_3^-) together with the reaction of chlorine, Cl_2. with aqueous NaOH and the various disproportionation reactions involved;

(c) recall the behaviour of sodium halides with concentrated sulphuric acid (the formation and subsequent reactions of HX, the products and their oxidation states) and explain the differences in terms of $E^{\ominus}$ values;
(*Equations not required*)

(d) show a knowledge of the relationship of the bleaching and bacterial action of Cl_2 and chlorate(I) (ClO^-) to their oxidising power and the use of chlorate(V) as a weed killer;

(e) show understanding of the chemistry of Group VII in terms of (i) the decreasing electronegativity, and (ii) the increasing stability of the higher oxidation states (e.g. IO_3^- vs. $C1O_3^-$), on descent of the group;

(f) show an awareness of the very wide range of halogen containing compounds of commercial and industrial importance.

TOPIC 21 TRANSITION ELEMENTS

21.1 Electronic configuration of the *d* block elements Sc to Zn.
Transition elements. General properties. Variable oxidation state. Catalytic power.

21.2 Complex formation and the shapes of such species. Coloured ions. Reaction of cations in solution with NaOH(aq).

21.3 Industrial and biological importance.

Learning outcomes **Topic 21**

Candidates should be able to:

(a) recall that transition elements (except Cu) possess partly filled *d*-orbitals and derive the electronic configuration of any first row transition metal ion using a Periodic Table;

(b) recall that 4*s* electrons are lost more readily than 3*d* electrons in ion formation;

(c) explain why various oxidation states are possible in transition elements;

(d) recall that transition metals and their compounds are often good catalysts, give an example, and explain why this is so in terms of partially filled *d*-shells and variable oxidation states;

(e) recall that many complexes are formed between transition metal ions and ligands, most of these are coloured,

e.g $[Cr(H_2O)_6]^{3+}$, $[Cu(H_2O)_6]^{2+}$, $[Cr(NH_3)_6]^{3+}$, $[FeCl_4]^{-}$, $[Fe(CN)_6]^{4-}$;

(f) describe the shape, bonding, colour and formulae of the approximately octahedral complex ions $[Cu(H_2O)_6]^{2+}$, $[Cu(NH_3)_4(H_2O)_2]^{2+}$ and the approximately tetrahedral ion $[CuCl_4]^{2-}$;

(g) (i) explain the origins of colour in transition metal complexes and give a qualitative account of this for octahedral 6-coordinate species in terms of the splitting of the *d*-orbitals involved, and
(ii) show understanding of the spectroscopic consequences of (i) above and explain that in many cases the colours of such transition metal complexes arise from *d-d* transitions between the split *d*-orbital levels *;

(h) describe the reactions of Cr^{3+}, Fe^{2+}, Fe^{3+}, Cu^{2+}, and Zn^{2+} with excess OH^- †;

(i) show an awareness of the economic importance of transition metals and their importance as trace elements in living systems, and give one example of economic importance and one example of trace element importance.

Note:
† Balanced chemical equations are required.
* *The simple electrostatic model is adequate to account for the d-orbital splitting. Candidates should be able appropriately to allocate electrons to the split d-orbitals using the arrows in boxes technique (1(l)), but consideration of the factors leading to high or low spin behaviour will not be required.*

TOPIC 22. PERIODICITY

This topic is largely concerned with the trends in behaviour of both elements and compounds as a function of position within the Periodic Table.

22.1 Electronegativities, redox, acid-base properties, reactions of elements with oxygen, chlorine and water. Trends across periods. The behaviour of chlorides towards water.

22.2 Covalency maxima.

22.3 Ionic or covalent behaviour, metallic or non-metallic nature and amphoteric character.

22.4 Electron deficient species of Group III.

22.5 Trends in the *s* - block: reactions of the elements (Li - Cs) with water, normal oxides and hydroxides. Flame tests.

Learning outcomes: **Topic 22**

Candidates should be able to:

(a) appreciate that electronegativities generally increase from left to right across a period and decrease from top to bottom down a group, so that elements in the top right of the Periodic Table tend to be oxidising agents and those on the lower left reducing agents (c.f. 3.1 (h));

(b) appreciate that oxides of the elements tend to become more acidic from left to right across a period and that oxides and chlorides similarly tend to become more covalent from left to right across a period (c.f. 5.1 (c));

(c) recall and understand the reactions, if any, of
(i) oxygen with elements Na to S †,
(ii) chlorine with elements Na to S †,
(iii) water with elements Li to Ar †;

(d) recall and understand the reactivity towards water of the chlorides of the elements Na to S, particularly when reflecting the increasing tendency towards covalency moving across this period †;

(e) show understanding of why the maximum number of electron pairs which can surround a central atom is greater in Row 3 (Na-Ar) than in Row 2 (Li-Ne);

(f) demonstrate knowledge of how amphoteric character is related to ionic or covalent bonding, to metallic or non-metallic behaviour and to electronegativities;

(g) recall, understand and rationalise the incidence of covalent bonding in compounds of Be;

(h) recall that amphoteric character is largely concentrated in the region comprised by the elements Be, Zn, Al, Ga, In, Sn and Pb; recall and understand typical examples of amphoteric behaviour for the elements Be, Zn, Al, Sn and Pb †;

(i) understand the electron deficient nature of Group III systems such as BF_3, BCl_3 and monomeric $AlCl_3$, their electron acceptor properties and the cause of the ready formation of the Al_2Cl_6 dimer;

(j) appreciate that Al may exhibit either mainly ionic or mainly covalent bonding in its compounds.

Note:

† Balanced chemical equations are required.

TOPIC 23. CHEMICAL KINETICS

23.1 Obtaining and analysing rate data. Rate equations. Rate constants. Orders of reactions. Experimental methods.

23.2 The use of kinetic data in establishing reaction mechanisms.

Learning outcome **Topic 23**

Candidates should be able to:

(a) describe in outline the variety of methods for studying reaction kinetics e.g. the iodine clock reaction, colorimetry and other spectroscopic techniques, pressure and volume changes;

(b) calculate rates from numerical or graphical data (including drawing tangents to concentration-time curves);

(c) recall and apply the general rate equation, rate = $k[A]^m [B]^n$, define rate, rate constant and reaction order, and give the units of rate constants up to, and including, second order;

(d) (i) calculate integral orders of reaction (0, 1 or 2) from given rate data;
(ii) appreciate that orders of reaction may only be found through rate measurement and not from stoichiometric equations;

(e) distinguish clearly between rate and equilibrium and between the effects of temperature change on rates and on the position of equilibrium (cf Topic 24);

(f) explain and use the concept of rate determining step;

(g) deduce the kinetics that would apply to a suggested mechanism or, conversely, suggest a mechanism consistent with a determined or given reaction order in simple cases and show an understanding of how kinetic evidence may support a proposed mechanism.

TOPIC 24 ENERGY CHANGES AND EQUILIBRIA

24.1 Enthalpy changes of lattice formation and breaking. Enthalpy changes of solution. Application of Hess's Law (Born-Haber cycle) to the formation of simple ionic compounds.

24.2 Quantitative treatment of gaseous and solution equilibria, including the use of K_p and K_c.

24.3 Lowry- Br□nsted theory; strong and weak acids and bases.
Dissociation constants of weak acids, K_a
The definition of pH, pH calculations, pH profiles and acid-base titrations.

24.4 Buffer solutions; salt solutions. Indicators and their uses.

Learning outcome **Topic 24**

Candidates should be able to:

(a) understand the use of the terms enthalpy change of atomisation, lattice formation and breaking, hydration and solution (formal definitions are not required);

(b) explain how enthalpy changes of solution are related to lattice breaking enthalpies and hydration enthalpies of the ions;

(c) show understanding of the way in which the solubilities of ionic solids in water depend upon the balance between the lattice breaking enthalpies and the hydration enthalpies of the ions;

(d) apply Hess's Law (Born-Haber cycle) to the formation of simple ionic compounds and carry out appropriate calculations (data will be supplied as necessary);

(e) recognise that the most stable ionic compounds will be those formed most exothermically from their elements;

(f) calculate values of K_p and K_c, or of quantities present at equilibrium, given appropriate data (no manipulations of mole fraction or of degree of dissociation will be required);

(g) show ability to use given or calculated values of K_p and K_c to estimate qualitatively the location of the position of equilibrium for a system;

(h) understand and apply the Lowry-Br□nsted theory of acids and bases (limited to aqueous solutions);

(i) recall the definition of pH and calculate pH values from those of [H^+ (aq)] and vice versa;

(j) explain and use pH, K_w and K_a in calculations involving strong and weak acids, and use pH and K_w in calculations involving strong bases;

(k) recall the forms of the acid - base titration curves for the systems: strong acid /strong base (e.g. HCl NaOH), strong acid/ weak base (e.g. HCl/NH_3) and weak acid/strong base (e.g. $CH_3COOH/NaOH$), explaining these in terms of the appropriate acid and base strengths;

(l) understand the mode of action of buffer solutions, exemplified by the CH_3COONa / CH_3COOH system, appreciate their importance, and carry out appropriate pH calculations;

(m) recall and explain qualitatively typical pH values exhibited by solutions of the salts NaCl, CH_3COONa and NH_4Cl;

(n) understand the working of an indicator and select suitable indicators for specified acid-base titrations, given appropriate pH values.

4 PRACTICAL COURSEWORK

4.1 Preamble

Emphasis should be placed on demonstrating the relationship of practical work to the theoretical content of the syllabus. Practical coursework assessment should not be an isolated series of chemical tests, but an integrated part of the normal teaching program.

The practical work to be undertaken should develop, enhance and extend the skills which the candidates have already acquired from Sc1 of Key Stage 4 of the National Curriculum for Science.

Particular attention should be paid to coursework which will enable candidates to use their theoretical knowledge in planning, implementing and interpreting experimental work, especially in the A2 year for fulfilling the synoptic approach of objective (d) on p.58

The detailed arrangements for submission of evidence required by the Board will be published in *Examination Timetables* (Section: AS and A GCE Coursework Submission Dates) and in instructions accompanying the appropriate stationery.

4.2 Assessment Objectives

The following objectives apply to the experimental and investigative work (objective (c), p.57) in both the AS and A2 years.

4.2.1 Planning

Candidates should:

(a) identify and define the nature of a question or problem using available information and knowledge of chemistry;

(b) retrieve and evaluate information from multiple sources, including computer databases where appropriate;

(c) choose effective and safe procedures, selecting appropriate reagents and apparatus, with due regard to precision of measurement, purity of reagents and products, scale of working and the control of variables.

4.2.2 Implementing

Candidates should:

(a) demonstrate the manipulative skills needed for specific chemical techniques used in the laboratory, showing a due regard for safety;

(b) make and record sufficient relevant observations and measurements to an appropriate degree of precision using, where appropriate, logging and processing of data, using information technology;

(c) carry out work in appropriate contexts, involving:
  (i) techniques of preparation and purification;
  (ii) qualitative and quantitative exercises.

4.2.3 Analysing evidence and drawing conclusions

Candidates should:

(a) present work appropriately in written, graphical or other forms, using chemical nomenclature and terminology;

(b) interpret information gathered from experimental activities including:

  (i) manipulation of data to give meaningful results, including any necessary calculations;
  (ii) recognition of patterns and trends in a set of data or information;
  (iii) identification of sources of error and recognition of the limitations of experimental measurements;

(c) draw valid conclusions by applying their knowledge and understanding of chemistry, reporting quantitative data to an appropriate number of significant figures.

4.2.4 Evaluating evidence and procedures

Candidates should:

(a) assess the reliability of their data and the conclusions drawn from it;

(b) evaluate the techniques used in the experimental activity, recognising the limitations of these.

4.3 Weighting of the Assessment Objectives

The **overall** contribution of the four skills to the assessment of the experimental and investigative work in the AS and A2 years should lie in the following % ranges:

	AS	A2	A
• Planning	10-20	20-30	15-25
• Implementing	40-50	40-50	40-50
• Analysing evidence and drawing conclusions	20-30	20-30	20-30
• Evaluating evidence and procedures	10-15	15-25	13-20

In the AS year the practical chemistry assessments are designed (see 4.5 below) to address areas of the subject requiring more quantitative treatment than that usually used at GCSE, and as a consequence more emphasis is placed on proficiency in particular techniques. In the A2 year, when candidates have acquired a fuller base in both theory and experiment, the subject material is necessarily somewhat more demanding, and greater opportunities are provided for more significant planning and evaluation by the candidates. By virtue of their enhanced chemical background candidates are now also in a position to address those aspects of synoptic assessment, which are contained in the coursework.

4.4 Quality of Written Communication

Up to 3 marks should be awarded in the AS and A2 coursework for the quality of written communication. The criteria for awarding these marks are as follows:

Mark Candidates:

3 demonstrate a high performance in communicating their experimental and investigative activities clearly and logically; they use a wide range of specialist terms adeptly and with precision; they spell, punctuate and use the rules of grammar with almost faultless accuracy.

2 demonstrate an intermediate performance in communicating their experimental and investigative activities clearly and logically; they use a good range of specialist terms with facility; they spell, punctuate and use the rules of grammar with considerable accuracy.

1 demonstrate a threshold performance in communicating their experimental and investigative activities with clarity; they use a limited range of specialist terms appropriately; they spell, punctuate and use the rules of grammar with reasonable accuracy.

0 do not demonstrate quality of written communication that is worthy of a mark.

4.5 Statement of Requirements

4.5.1 *Number and Nature of Assessments*

Advanced Subsidiary - Assessment Unit CH3b/c

Candidates will be required to undergo **two** assessments of their ability in practical chemistry.

One experiment should be selected covering the area of

- stoichiometry

and one experiment from either the area of

- thermochemistry or kinetics

that reflect the content of the AS modules CH1 and CH2.

Each experiment will be equally weighted and will contribute to assessment objective (c) p.57.

Advanced GCE Part 2 - Assessment Unit CH6b/c

Candidates will be required to undergo **two** assessments of their ability in practical chemistry.

One experiment should be selected covering the broad areas of inorganic chemistry and organic chemistry and the associated physical principles in the A2 year. The experimental and investigative activities will include opportunities to draw together knowledge and understanding and skills from across the full AS/A specification in a synoptic manner. Both experiments will be equally weighted and will contribute equally to the assessment objectives (c) and (d), pp. 57 and 58 (c.f. Table, p.62).

4.5.2 Entry Options

For both AS and A2 centres have the option of supplying coursework which is

either
totally internally designed/a mixture of internally designed experiments and those supplied by the Board in *'The Coursework Unit'* booklets for AS/A. Centres are required to **mark all** this coursework and then supply the **marked** coursework for **moderation** by the date given in the *Examination Timetables* booklet. The entry option is Unit CH3b (AS) and CH6b (A2).

In such an instance fully detailed experiments, mark schemes and skill area analysis must be forwarded to the AS/A level Section at the Board by the 31st of October in the year immediately preceding the AS/A award.

or
totally contained within *'The Coursework Unit'* booklets for AS/A. Centres should then supply their coursework for external marking by the Board by the data given in the *Examination Timetables* booklet. The entry option is Unit CH3c (AS) and CH6c (A2).

- The coursework experiments and corresponding mark schemes for assessment unit CH3c (AS) and CH6c (A2) will be available to a **centre**, by request from the A level section, upon registration with the Board.

4.5.3 Timing of Assessments

Normally, on average, a double period will be required to carry out an AS experiment and two double periods an A2 experiment. However, no strict time limit is envisaged.

Candidates may be assessed at any time during the course, in accordance with the following considerations and requirements:

- candidates must be given an opportunity to acquire a given skill before they are assessed;

- it is not necessary to assess all candidates at the centre in the same sessions nor need the same exercises be used;

- the date of submission of coursework marks will be in early May of the year of examination. This date will be printed each year in the *Examination Timetables* booklet.

4.5.4 Repeated assessment

A candidate can present a specific experiment for assessment once only, and not improve the standard by repeated presentation for assessment.

Repetition of the same experiment should only be allowed in the case of either faulty equipment or chemicals, which have affected the candidate(s) results.
When a candidate is allowed to repeat an experiment, both the original and the repeated scripts should be retained, (and sent, if so required, for moderation) together with an explanation of the problems encountered.

4.5.5 Recording of the assessment

The Board will issue, to each centre, forms CASP, CAP, ECS 3c and ECS 6c (see examples at the back of this booklet).

- CASP (AS) is for the recording of the marks gained in each exercise by each candidate entered for assessment unit CH3b. CAP (A2) is for the recording of marks gained in each exercise by each candidate entered for assessment unit CH6b. Each candidate's final coursework mark is to be submitted as a total mark gained by two exercises in the case of assessment unit CH3b (AS) and a total mark gained by two exercises in the case of unit CH6b (A2).
  Estimated marks are not allowed under any circumstances.

- ECS 3c (AS) is the candidate cover sheet which should be attached to the two experiments submitted, for external marking, by each candidate for assessment unit CH3c. ECS 6c is the candidate cover sheet which should be attached to the two experiments submitted, for external marking, by each candidate for assessment unit CH6c.

  CASP (AS) and CAP (A2) are to be submitted to the moderator, ECS 3c (AS) and ECS 6c (A2) to the examiner, as appropriate, by the date printed each year in the *Examinations Timetables* booklet.

  NOTE
  Within a scheme of internal coursework it should be possible, under normal circumstances, to accommodate for occasional absence by offering an alternative opportunity for assessment.
  (See Section 4.5.8 for candidates with prolonged absences etc.)

- Authentication

  The teacher is required to sign CASP (AS) and/or CAP (A2) and/or ECS 3c and/or ECS 6c on which the candidates' marks are recorded, in order to authenticate the coursework to be each candidate's own work.

  To be able to so authenticate coursework, all the work must have been carried out under centre supervision and the teacher must, at all other times, have retained the scripts.

  Where it has been necessary to supply assistance to an individual candidate, this must be recorded on the candidate's work, by the supervisor, and marks deducted accordingly. At the start of the course, candidates must be informed of the WJEC regulations concerning malpractice.

4.5.6 Retention of coursework

Centres should retain candidates' coursework until after the results of the examination are published and any appeals have been completed.

4.5.7 Re-use of marks

- Coursework assessments marks may be carried forward from one year to the next provided that they are carried forward once only. Form CF:CHEM, distributed by the A level section, should be used for this purpose. (Note that papers CH3a and CH6a **cannot** be carried forward and must be retaken under these circumstances.)

- Enhanced performance for Units CH3b (AS) and CH6b (A2):

  In the case of candidates re-entering the examination in the year immediately following their first attempt, centres must submit for AS two and A2 two assessments. These must include one or two new assessments at AS and one or two new assessments in the case of A2. (CASP and/or CAP forms should be used.)

  A mixture of CF:CHEM with CASP and/or CAP forms is **not** permissible.

4.5.8 Candidates in specific circumstances

- Centre transfer: The record of practical work done by candidates transferring centres during the course should be obtained from the original centre, and the work re-marked, if necessary, for internal moderation.

- Candidates in special circumstances: The centre should complete the prescribed form for candidates who have disabilities or who may merit special consideration for other reasons.

- Other cases: Centres with candidates whose circumstances differ from those above should communicate with the Board as soon as possible.

4.6 Moderation of Units CH3b (AS) and CH6b (A2)

4.6.1 Objective

The purpose of moderation is to ensure that the assessments carried out locally are brought to a common standard across all centres.

4.6.2 Preliminary internal moderation

In centres where more than one teacher is involved in assessment, preliminary internal moderation to ensure a common standard for the centre must be carried out before the marks are submitted to the Board. This can be done by the trial marking of common pieces of work and the use of reference and archive materials. **The rank order** of candidates supplied on CASP (AS) and CAP (A2) must be that for **the centre as a whole**.

4.6.3 Submission to the Moderator

Centres will be informed of the name and address of the moderator to whom the following items should be sent:

- the completed form(s) CASP (AS) and/or CAP (A2), with the **candidates in the sample highlighted**;
- full details of the assessed experiments; *
- marking schemes; *
- teacher results for experiments involving quantitative data;
- **all** the original marked coursework of a **sample** of candidates including the date(s) on which it was carried out. The allocation of each mark in each experiment must be clearly discernible on each candidate's work.

* the experiments and marking schemes **must** have received written approval from the WJEC by the 31st of October in the year immediately preceding the AS/A award (Section 4.5.2).

The selection of candidates' work in the sample must be as stated in the *GCE AS/A* Coursework *Internal Assessment* Booklet of the WJEC.

The date by which the above items must be submitted to the moderator will be printed each year in the *Examination Timetables* booklet.

4.6.4 Inspection of the marked sample of coursework

The moderator will inspect the marked sample of coursework and only if the sample does not accord with the principles and requirements of the Board will the centre be required to submit the work of all its candidates. In such a case, it is possible that all the marks at the centre will need adjustment.

4.6.5 Inspection of candidates' coursework

All centres are required to send **all** the **assessed** practical coursework of a **sample** of its candidates. It is essential that the work of each candidate bears the following information clearly on the front page:

* the candidate's name;
* the candidate's number;
* the centre name;
* the centre number.

In addition, to assist the moderation process, the coursework should be grouped by candidate (not by experiment).

4.6.6 Amended marks

If any marks submitted by a centre have been amended, the centre will be informed of the changes and will receive a report submitted by the moderator. The moderator may also wish to draw the attention of other centres to aspects of their assessments. If no comments are received by the centre, it may be assumed that the assessment was satisfactory.

4.6.7 Return of work

All the materials submitted for **moderation** by the centre will be returned early in the Autumn term following the examination.

4.7 Information Technology

Practical coursework offers the opportunity for centres, to encourage candidates to use information technology. In the case of assessed exercises this could be up to one experiment for AS and one experiment for A2. The candidate would be expected to comment on the limitations of any software used.

When a Word Processing package is used e.g. in order to improve presentation, all the candidate's original work, done under supervised conditions, should be retained and sent, if so required, by the sampling process for moderation.

4.8 Safety and Hazardous Substances

Supervisors must, of course, themselves ensure safe working procedures are always followed and that all practical work fulfils the requirements of the COSHH regulations and the Health and Safety at Work Act.

Attention is drawn to the publication, *Control of Substances Hazardous to Health (COSHH): Guidance to Schools* [ISBN 0 11 885511 5] published by the Health and Safety Commission, and available from HMSO and other booksellers. This booklet is published to help employers and managers in the school sector understand and apply the responsibilities they are assuming under current safety legislation; it contains an appendix of references. There are a number of publications, including one published by The Royal Society of Chemistry, available from booksellers and libraries for all users of chemicals. The following are cited as useful in dealing with specific substances and situations likely to be encountered in educational establishments:

Safety in Science Education DfEE 1996 HMSO [ISBN 0 11 270915X]
Topics in Safety (2nd edition) [ISBN 0 86357 104 2] from the Association for Science Education, College Lane, Hatfield, Herts AL10 9AA

Hazcards from CLEAPSS, Brunel University, Kingston Lane, Uxbridge IB8 3PH

5 *MATHEMATICAL REQUIREMENTS*

Numeracy rather than an extensive knowledge of mathematics is required. Candidates should be competent in the techniques described below and in the appropriate use of calculators. Material relevant to the A level core is given in bold type.

(a) Arithmetic and Computation

Candidates should be able to:

- perform arithmetic and algebraic addition, subtraction, multiplication and division;
- recognise and use expressions in decimal and standard form;
- use ratios, fractions and percentages;
- make estimates of the results of calculations (without using a calculator);
- **use calculators to find and use x^n, $1/x$, $\sqrt{x}$, e^x, $log_{10}x$ (for pH calculations).**

(b) Handling date

Candidates should be able to:

- appreciate the techniques used in numerical work to ensure that significant figures are neither unnecessarily lost nor used beyond what is justified;
- find arithmetic means.

(c) Algebra

Candidates should be able to:

- formulate simple algebraic equations as mathematical models;
- change the subject of an equation;
- substitute numerical values into algebraic equations using appropriate units for physical quantities;
- **use logarithms in relation to quantities which range over several orders of magnitude**.

(d) Geometry

Candidates should be able to:

- appreciate angles and shapes in regular two and three-dimensional forms;
- visualise and represent two and three-dimensional forms including two-dimensional representations of three-dimensional objects;
- understand the symmetry of two **and three-dimensional** shapes.

(e) Graphs

Candidates should be able to:

- translate information between graphical, numerical and algebraic forms;
- plot two variables from experimental or other data;
- understand that $y = mx + c$ represents a linear relationship;
- determine the slope and intercept of a linear graph;
- **draw and use the slope of a tangent to a curve as a measure of rate of change.**

6 *KEY SKILLS*

Key skills are integral to the study of chemistry and for candidates pursuing a separate key skills qualification the content and coursework of the specification provide the **opportunity**, if so desired, to develop **and generate evidence** for assessing the key skills of communication, application of number, information technology, working with others, improving own learning and performance and problem solving. Such positions of opportunity, for each of the key skills at level 3 and for communication, application of number and information technology at levels 1-3, have been signposted in the appendix where they are cross-referenced to the content of the specification.

There is no requirement for a separate assessment of key skills for the AS/A GCE Chemistry qualification.

7 ASSESSMENT OBJECTIVES

The AS/A GCE examination will be designed to test the following abilities.

(a) *Knowledge with understanding*

Candidates should be able to:

(i) recognise, recall and show understanding of specific chemical facts, terminology, principles, methods, concepts and practical techniques;

(ii) draw on existing knowledge to show understanding of the responsible use of chemistry in society;

(iii) select, organise and present relevant information clearly and logically, using specialist vocabulary where appropriate;

(b) *Application of knowledge and understanding, analysis, synthesis and evaluation*

Candidates should be able to:

(i) 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;

(ii) interpret and translate, from one form into another, data presented as continuous prose or in tables, diagrams and graphs;

(iii) carry out relevant calculations;

(iv) apply chemical principles and concepts to new situations including those related to the responsible use of chemistry in society;

(v) assess the validity of chemical information, experiments, inferences and statements.

(c) *Experiment and investigation*

Candidates should be able to:

(i) devise and plan experimental and investigate activities, selecting appropriate techniques;

(ii) demonstrate safe and skilful practical techniques;

(iii) make observations and measurements with appropriate precision and record these methodically;

(iv) 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.

(d) *Synthesis of knowledge, understanding and skills*

Candidates should be able to:

(i) 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;

(ii) use chemical skills in contexts which bring together different areas of the subject.

8 SCHEME OF ASSESSMENT

Advanced Subsidiary

Candidates will be required to take assessment units CH1, CH2 and CH3. Assessment units CH1 and CH2 will contain two equally weighted papers, CH1 and CH2, which will assess the subject content of the corresponding modules CH1 and CH2. Unit CH3 will be comprised of paper CH3a which will assess the theory - experiment interface and CH3b/c practical coursework.

For aggregation the weighting of the assessment units are as shown in the following table.

	ASSESSMENT UNITS			
	CH1	**CH2**	**CH3**	
			a	**b/c**
AS	35%	35%	10%	20%

The Papers

All written AS papers will be externally assessed. CH1 and CH2 will have a maximum available mark of 66 and be of 1 hour 30 minutes duration. CH3a will have a maximum available mark of 30 and be of 45 minutes duration.

Each paper will consist of a series of compulsory questions:

CH1 and CH2 will contain four structured questions carrying a total of 56 marks, the remainder will be objective questions.

CH3a will contain about four short answer questions.

The assessment unit CH3a will be concerned with the theory-experiment interface regarding the content, where appropriate, of teaching modules CH1 and CH2, and is aimed to test the candidate's ability to integrate laboratory work and related theory.

The unit will assess the application of knowledge, understanding and skills rather than direct recall.

The areas indicated below readily lend themselves to exploration in the laboratory:

- Acid-base titrations (2(d)); (2(e)); (2(f)); (9(h));
- Reactions of aqueous solutions of Mg^{2+}, Ca^{2+}, and Ba^{2+} with the anions OH^-, CO_3^{2-} and SO_4^{2-} (5.2 (b)); flame tests (5.2 (e));
- Redox reactions of Cl_2 and Br_2 (5.2 (k)); The use of Ag^+(aq) followed by NH_3(aq) to identify Cl^- (aq), Br^- (aq) and I^- (aq) ions (5.2 (n).
- Enthalpy changes in aqueous solution (6(d));
- Oxidation of primary alcohols (7(h));
- Functional group recognition tests (7(i));
- Typical reactions of alkenes (8(f)), (8(g));
- Experiments to determine rates and concentration dependence of suitable chemical reactions (10(b)); (10(c));

Questions may be set on other experiments where basic principles are involved, however, in such cases all relevant experimental details will be supplied with all written papers.

Questions will be set on the AS papers not only to test knowledge and understanding of the subject matter, but also to test the ability to apply such knowledge to problems and relevant situations, which need not necessarily be specified in the syllabus. The environmental, industrial, social and technological application of chemistry included in the specification, and health and safety issues related to chemistry, will be woven into questions on the module papers where appropriate.

A Periodic Table containing the symbols, proton numbers and relative atomic masses will be supplied with all written papers.

Relationships between assessment components and assessment objectives.

The marks allocated in the assessment units to the assessment objectives will be **approximately** as follows:

	ASSESSMENT UNITS			
ASSESSMENT OBJECTIVE	**CH1 + CH2**	**CH3a**	**CH3b/c**	**WEIGHTING**
KNOWLEDGE & UNDERSTANDING	50	0		50
APPLICATION, ANALYSIS SYNTHESIS & EVALUATION	20	10		30
EXPERIMENT & INVESTIGATION			20	20
WEIGHTING	70	10	20	100

It is intended that the two papers CH1and CH2 will be **approximately** equally weighted. However, minor variation may occur in the percentages stipulated but every effort will be made to maintain the overall objective weightings.

Quality of Written Communication

The candidates' answers in continuous prose will be awarded marks on all papers for the Quality of Written Communication used in accordance with the assessment objectives (a) (iii) and (b) (i).

The coursework component will have marks awarded for the Quality of Written Communication used in accordance with the assessment objective (c) (iv). (Reference: *Practical coursework Section* 4.4)

Advanced Level

The Advanced level specification consists of two parts, AS and A2, both contribute 50% of the total A level marks.

Part 1 (Advanced Subsidiary) may be taken separately and added later to A2 or both AS and A2 may be taken together.

In addition to assessment units CH1, CH2 and CH3, which are in common with AS, candidates will be required to take assessment units CH4 and CH5 (which will assess the subject content of the corresponding CH4 and CH5 modules) and unit CH6. Unit CH6 will be comprised of CH6a, the synoptic paper, and CH6b/c practical coursework.

For aggregation the weighting of the assessment units are as shown in the following table.

	ASSESSMENT UNITS							
	CH1	CH2	CH3 a	CH3 b/c	CH4	CH5	CH6 a	CH6 b/c
A	17½%	17½%	5%	10%	15%	15%	10%	10%

The Papers

Papers CH1 and CH2 are in common with the AS examination.

All written A2 module papers (CH4, CH5, CH6a) will be externally assessed.

CH4 and CH5 will have a maximum available mark of 75 and be of 1 hour 40 minutes duration. CH6a will have a maximum available mark of 50 and be of 1 hour 10 minutes duration.

Each A2 paper will consist of a series of compulsory questions:

CH4 and CH5 will contain:

(i) two/three structured questions carrying a total of 35 marks;

(ii) two free response questions each carrying 20 marks.

CH6a (Synoptic) will contain:

(i) one question carrying 10 marks;

(ii) one comprehension question carrying 15 marks;

(iii) two structured questions carrying a total of 25 marks.

The synoptic assessment, which involves the understanding and application of chemical principles learned in different parts of the GCE course, will be examined in the A2 papers CH4, CH5 and CH6a where its weighting will be 16.7%, 16.7% and 100% respectively.

Questions will be set on any of the papers not only to test knowledge and understanding of the subject matter, but also to test the ability to apply such knowledge to problems and relevant situations, which need not necessarily be specified in the syllabus. The environmental, industrial, social and technological application of chemistry included in the syllabus, and health and safety issues related to chemistry, will be woven into questions on the module papers where appropriate. Questions involving the planning of experimental procedures, the analysis and evaluation of data thus arising and the explanation and rationalisation of experimental processes may also feature, as appropriate, in any of the theory papers and should **not** be regarded as confined to Paper CH3a.

A Periodic Table containing the symbols, proton numbers and relative atomic masses will be supplied with all written papers. Infrared and nuclear magnetic resonance data will be supplied with papers CH4 and CH6a.

Relationships between assessment components and assessment objectives.

The marks allocated in the examination components to the assessment objectives will be **approximately** as follows:

	ASSESSMENT UNITS							
	AS			A2				
ASSESSMENT OBJECTIVE	**CH1 + CH2**	**CH3a**	**CH3b/c**	**CH4**	**CH5**	**CH6a**	**CH6b/c**	**WEIGHTING**
KNOWLEDGE & UNDERSTANDING	25	0		7.5	7.5	0		40
APPLICATION, ANALYSIS, SYNTHESIS & EVALUATION	10	5		5	5	0		25
EXPERIMENT & INVESTIGATION			10				5	15
SYNOPTIC				2.5	2.5	10	5	20
WEIGHTING	35	5	10	15	15	10	10	100

It is intended that AS assessment units (CH1, CH2) will be **approximately** equally weighted. However, minor variation may occur in the percentages stipulated for the components, but every effort will be made to maintain the overall objective weightings.

Quality of Written Communication

The candidates' answers in continuous prose will be awarded marks on all papers for the Quality of Written Communication used in accordance with the assessment objectives (a) (iii), (b) (i) and (d) (i).

The coursework component will have marks awarding for the Quality of Written Communication used in accordance with the assessment objective (c) (iv). (Reference: *Practical Coursework Section 4.4*.)

Nomenclature

In the question papers, units and the system of notation will conform with those recommended in the SI system. (Reference: *Signs, Symbols & Systematics 16-19 Science, 2000*, The Association for Science Education, available from ASE, College Lane, Hatfield, Herts, AL10 9AA.) In general, compounds throughout the syllabus are named according to ASE recommendations but trivial and common names are included in brackets where appropriate. Both recommended systematic names and trivial or common names will also be used in question papers where appropriate, and candidates should therefore be able to convert such names to formulae for simple compounds, e.g. calcium carbonate to $CaCO_3$, magnesium hydroxide to $Mg(OH)_2$. When more than one oxidation state commonly occurs this will be indicated in the naming, e.g. phosphorous(V) chloride for $PC1_5$, potassium manganate(VII) for $KMnO_4$.

Availability of Assessment Units

Assessment units CH1, CH2 and CH4 will be available in January and June. Units CH3, CH5 and CH6 will be available in June only. The assessment calendar is shown below.

Availability of Assessment Units		
Unit	**January 2004 & each subsequent year**	**June 2004 & each subsequent year**
CH1	✓	✓
CH2	✓	✓
CH3		✓
CH4	✓	✓
CH5		✓
CH6		✓

9 *AWARDING AND REPORTING*

- The AS examination will be set at the standard to be expected of a candidate at the end of the first year of a two year A level GCE course.
- Each AS/A assessment unit will be graded on a five point grade scale: A, B, C, D and E. Candidates who fail to reach the minimum standard for grade E will be recorded as U (unclassified), and will not receive a qualification certificate.
- Where a module is re-sat, the better result will count towards the final award. Candidates may re-sit the whole qualification more than once.
- Individual assessment unit results, prior to certification of the qualification, have a shelf-life limited only by the shelf-life of the specification.
- Aggregation will be available in June.
- The Advanced A2 GCE examination must contain a 20% assessment of the synoptic objective.

10 GRADE DESCRIPTIONS

Advanced GCE

The following grade descriptions indicate the level of attainment characteristic of the given grade at Advanced GCE. (Reference: *Subject Criteria for Chemistry ACCAC/CCEA/QCA June 1999).* They give a general indication of the required learning outcomes at each specified grade. The descriptions should be interpreted in relation to the content outlined in the specification; 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 performances 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 fundamental 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 chemistry 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 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 skillful 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.

APPENDIX

WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education

CASP

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol

ASSESSMENT UNIT CH3b

Teacher designed and assessed – WJEC pre-approved Practical Work 200 ...

Name of Centre ____ Centre Number _____________________

	Expt. Group	**STOICHIOMETRY**	**THERMOCHEM. OR KINETICS**		**Total Centre Mark (Max. 100)**	**Quality of Written Comm-unication (Max. 3)**	**Final Mark (Max. 103)**	**Board use Only**
	Total number of candidates =	**Mark**	**Mark**	**OR Mark**				
Candidate's number	**Candidate's Name (Surname First) RANK ORDER**	**Maximum Mark Available for each Experiment is 50**						

DECLARATION (1) I certify that the work of the above candidates has been carried out under the conditions required by the WJEC, that it has been supervised throughout and that, to the best of my knowledge and belief, it has been produced by each candidate's own effort.

**Delete as necessary* (2) I confirm that internal moderation **was/was not* required **and has been carried out*.

Signed ______________________________________ (Subject Teacher) Signed ______________________________________ (Head Teacher) Date ____________________

This form should be **sent to the moderator**, by the date given in the Examination Timetables Booklet.

WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education

CAP

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol

ASSESSMENT UNIT CH6b

Teacher designed and assessed – WJEC pre-approved Practical Work 200 ...

Name of Centre ____ Centre Number _____________________

		INORGANIC	ORGANIC	Total Centre Mark (Max. 100)	Quality of Written Comm-unication (Max. 3)	Final Mark (Max 103)	Board Use Only
	Expt. Group						
	Total number of candidates =	**Mark**	**Mark**				
Candidate's Number	**Candidate's Name (Surname First) RANK ORDER**	Maximum Mark Available for each Experiment is 50					

DECLARATION (1) I certify that the work of the above candidates has been carried out under the conditions required by the WJEC, that it has been supervised throughout and that, to the best of my knowledge and belief, it has been produced by each candidate's own effort.

**Delete as necessary* (2) I confirm that internal moderation **was/was not* required **and has been carried out*.

Signed ____________________________________ (Subject Teacher) Signed ____________________________________ (Head Teacher) Date ____________________

This form should be **sent to the moderator**, by the date given in the Examination Timetables Booklet.

WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education
Advanced Subsidiary

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol
Uwch Gyfrannol

ECS 3c

AS CHEMISTRY
ASSESSMENT UNIT CH3c

CANDIDATE COVER SHEET

EXTERNALLY MARKED COURSEWORK 200…

Centre Name: ______________________ Centre Number: ____________

Candidate's Name (in full): ______________________ Candidate's Number: ____________

		To be Completed by the Candidate		Examiner Only	
		Title of Experiment (in brief)	**Expt. No.**	**Mark**	
	Section A				
Either	**Section B**				
Or	**Section C**				
					Written Communication
					TOTAL MARK

AS Coursework for **External** marking **must** consist of **two** experiments **only**, which are **both taken from the WJEC AS Coursework Booklet**. These two experiments should be **attached** behind the cover sheet *using toggles/ treasury tags. Plastic wallets should* ***not*** *be used*.

Declaration by candidate

The attached coursework, with the exceptions stated, is my own unaided work.

Signed: ______________________ Date: ______________

Declaration by teacher or lecturer

I certify that the work of the above candidate has been carried out under the conditions required by the WJEC, that it has been supervised throughout and that, to the best of my knowledge and belief, with the exceptions stated, it has been produced by the candidate's own effort.

Signature: ______________________ Date: ______________

WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education
Advanced Level

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol
Safon Uwch

ECS 6c

A2 CHEMISTRY
ASSESSMENT UNIT CH6c

CANDIDATE COVER SHEET

EXTERNALLY MARKED COURSEWORK 200…

Centre Name: ______________________ Centre Number: ____________

Candidate's Name(in full): ______________________ Candidate Number: ____________

	To be Completed by the Candidate		Examiner Only	
	Title of Experiment (in brief)	**Expt. No.**	**Mark**	
Inorganic				
Organic				
				Written Communication
				TOTAL MARK

A2 Coursework for **External** marking **must** consist of **two** experiments **only**, which are **both taken from the WJEC A2 Coursework Booklet**. These two experiments should be **<u>attached</u>** behind the cover sheet *using toggles/ treasury tags. Plastic wallets should **<u>not</u>** be used.*

Declaration by candidate

The attached coursework, with the exceptions stated, is my own unaided work.

Signed: ______________________ Date: ______________________

Declaration by teacher or lecturer

I certify that the work of the above candidate has been carried out under the conditions required by the WJEC, that it has been supervised throughout and that, to the best of my knowledge and belief, with the exceptions stated, it has been produced by the candidate's own effort.

Signature: ______________________ Date: ______________________

THE EXEMPLIFICATION OF KEY SKILLS

The following tables give some examples of Chemistry contexts in which naturally occurring key skills evidence could be accumulated.

Note: If producing certain types of evidence creates difficulties due to disability or other factors, the candidate may be able to use other ways to show achievement. The candidate should ask the tutor or supervisor for further information.

COMMUNICATION: LEVEL 1

C1.1 TAKE PART IN A DISCUSSION			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context:** **(Topic No.)**
Take part in a **one-to-one** discussion and a **group** discussion about different, straightforward subjects.	• Provide information that is relevant to the subject and purpose of the discussion • Speak clearly in a way that suits the situation • Listen and respond appropriately to what others say.	Records from an assessor who observed each discussion and noted how the candidate met the requirements of the Unit, or an audio/video tape of the discussions.	• Petroleum; cracking; fuels. (8.3) • Factors affecting reaction rates. (10.1) • The beneficial role of chemistry to society and the environment. (11.4)

C1.2 INFORMATION GATHERING			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context:** **(Topic No.)**
Read and obtain information from **two** different types of documents about straightforward subjects, including at least **one** image.	• Read relevant material • Identify accurately the main points and ideas in material • Use the information to suit the purpose.	A record of what the candidate reads and why, including a note or copy of the image. Notes, highlighted text or answers to questions about the material read. Records of how the candidate used the information. *e.g.* in discussions for C1.1 or writing for C1.3.	• Petroleum; cracking; fuels. (8.3) • Factors affecting reaction rates. (10.1) • The beneficial role of chemistry to society and the environment. (11.4)

C1.3 WRITING			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context:** **(Topic No.)**
Write **two** different types of documents about straightforward subjects. Include at least **one** image in one of the documents.	• Present relevant information in a form that suits the purpose • Ensure text is legible • Make sure that spelling, punctuation and grammar are accurate so the meaning is clear.	The two different documents might include a letter, a short report or essay, with an image such as a chart or sketch.	• Petroleum; cracking; fuels. (8.3) • Factors affecting reaction rates. (10.1) • The beneficial role of chemistry to society and the environment. (11.4)

COMMUNICATION: LEVEL 2

C2.1a CONTRIBUTE TO A DISCUSSION			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context: (Topic No.)**
Contribute to a discussion about a straightforward subject.	• Make clear and relevant contributions in a way that suits the purpose and situation • Listen and respond appropriately to what others say • Help to move the discussion forward.	A record from an assessor who observed the discussion and noted how the candidate met the requirements of the Unit, or an audio/video tape of the discussion.	• Petroleum; cracking; fuels. (8.3) • Factors affecting reaction rates. (10.1) • The beneficial role of chemistry to society and the environment. (11.4)

C2.1b GIVE A SHORT TALK			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context: (Topic No.)**
Give a short talk about a straightforward subject using an image.	• Speak clearly in a way that suits the subject, purpose and situation • Keep to the subject and structure the talk to help listeners follow what the candidate says • Use an image to illustrate clearly the main points.	A record from an assessor who observed the talk, or an audio/video tape of the talk. Notes from preparing and giving the talk. A copy of the image used.	• Petroleum; cracking; fuels. (8.3) • Factors affecting reaction rates. (10.1) • The beneficial role of chemistry to society and the environment. (11.4)

C2.2 INFORMATION GATHERING			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context: (Topic No.)**
Read and summarise information from **two** extended documents about a straightforward subject. One of the documents should include **at least one** image.	• Select and read relevant material • Identify accurately the lines of reasoning and main points from text and images • Summarise the information to suit the purpose.	A record of what is read and why, including a note or copy of the image. Notes, highlighted text or answers to questions about the material read. Evidence of summarising information could include the candidate's notes for the talk, or one of the documents written.	• Petroleum; cracking; fuels. (8.3) • Factors affecting reaction rates. (10.1) • The beneficial role of chemistry to society and the environment. (11.4)

C2.3 WRITING			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context: (Topic No.)**
Write **two** different types of documents about straightforward subjects. One piece of writing should be an extended document and include **at least one** image.	• Present relevant information in an appropriate form • Use a structure and style of writing to suit the purpose • Ensure the text is legible and that spelling, punctuation and grammar are accurate, so the meaning is clear.	The two different documents might include a report or an essay, with an image such as a chart, graph or diagram, a business letter or notes.	• Petroleum; cracking; fuels. (8.3) • Factors affecting reaction rates. (10.1) • The beneficial role of chemistry to society and the environment. (11.4)

COMMUNICATION: LEVEL 3

C3.1a TAKE PART IN A DISCUSSION			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context: (Topic No.)**
Contribute to a group discussion about a complex subject.	• Make clear and relevant contributions • Listen and respond appropriately • Create opportunities for others to take part.	A record from someone who has observed discussion or has made video/ audio tape of discussion.	• The uses and hazards of radioactivity. (1.1) • Ethanol in a social context its uses and misuses. (15.1)

C3.1b MAKE A PRESENTATION			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context: (Topic No.)**
Make a presentation about a complex subject, using at least **one** image to show complex points.	• Speak clearly and use suitable style • Structure ideas and information • Use a range of techniques.	A record from someone who has observed discussion or has made video/ audio tape of discussion or preparatory notes with images.	• Environmental problems and their solution. Ozone depletion and the 'greenhouse' effect. (11.3) • Halogen compounds in commerce and industry. (20.2)

C3.2 INFORMATION GATHERING			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context: (Topic No.)**
Select and synthesise information from **two** extended documents that deal with a complex subject **One** of these documents should include at least one image.	• Select and read material that contains information needed • Identify accurately, and compare, the lines of reasoning and main points from texts and images • Synthesise the key information in a suitable form.	A record of what was read and why, including a note of the image. Notes, highlighted text or answers to questions about material read. Evidence of synthesising information from notes of a presentation or a written document.	• Technical and economic factors in the siting and operation of industrial processes. (11.1) • Industrial and biological importance of transition metals. (21.3)

C3.3 WRITING			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context: (Topic No.)**
Write **two** different types of documents about complex subjects. **One** piece of writing should be an extended document and include at least **one** image.	• Select and use appropriate style of writing • Organise relevant information clearly and coherently, using specialist vocabulary • Ensure text is legible, spelling, punctuation and grammar are accurate, and that meaning is clear.	The two different documents might include an extended essay or report, with an image such as a chart, graph or diagram and a letter or memo.	• The relationship between crystal structure - bonding - physical properties and uses. (4.5) • The beneficial role of chemistry to society and the environment. (11.4) • Industrial, commercial and medical uses of organohalogen compounds. Adverse environmental effects of CFCs. (14.4) • Periodicity; electronegativity, nature of oxides and chlorides, amphoteric character. (22)

APPLICATION OF NUMBER: LEVEL 1

N1.1 INTERPRET STRAIGHTFORWARD INFORMATION			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context: (Topic No.)**
Interpret straightforward information from **two** different sources. At least **one** source should be a table, chart, diagram or line graph.	• Obtain the information needed to meet the purpose of the task; and • Identify suitable calculations to get the results needed.	Description of the tasks and purposes. Copies of source material. A statement from an assessor who checked the accuracy of the candidate's measurements or observations (if this was done). Records of the information obtained and the types of calculations identified to get the results needed.	• Half-life in radioactivity. (1.1) • Chemical Kinetics. (10)

N1.2 CARRY OUT STRAIGHTFORWARD CALCULATIONS			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context: (Topic No.)**
Carry out straightforward calculations to do with: a. amounts and sizes; b. scales and proportion; c. handling statistics.	• Carry out calculations to the levels of accuracy the candidate has been given; and • Check the results make sense.	Records of the calculations (for a, b and c) and how the candidate checked them.	• Calculations involving reacting masses. (2.3)

N1.3 INTERPRET THE RESULTS OF CALCULATIONS			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context: (Topic No.)**
Interpret the results of the calculations and present her/his findings. The candidate must use **one** chart and **one** diagram.	• Choose suitable ways to present findings; • Present findings clearly; and • Describe how the results of the calculations meet the purpose of the task.	Descriptions of the findings and how the results of the calculations met the purpose of the tasks. At least **one** chart and **one** diagram presenting the findings.	• Half-life in radioactivity. (1.1) • Chemical Kinetics. (10)

APPLICATION OF NUMBER: LEVEL 2

Candidates must carry through at least **one** substantial activity that includes a number of straightforward **related tasks** for N2.1, N2.2 and N2.3.

N2.1 INTERPRET INFORMATION			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context:** **(Topic No.)**
Interpret information from **two** different sources, including material containing a graph.	• Choose how to obtain the information needed to meet the purpose of the activity; • Obtain the relevant information; and • Select appropriate methods to get the results needed.	A description of the substantial activity. Copies of source material, including the graph, and/or a statement from someone who has checked the accuracy of the candidate's measurements and observations. Records of the information obtained and the methods selected for getting the results needed.	• Half-life in radioactivity. (1.1) • Chemical Kinetics. (10)

N2.2 CARRY OUT CALCULATIONS			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context:** **(Topic No.)**
Carry out calculations to do with: a. amounts and sizes; b. scales and proportion; c. handling statistics; d. using formulae.	• Carry out calculations, clearly showing methods and levels of accuracy; and • Check methods to identify and correct any errors, and making sure the results make sense.	Records of calculations (for a, b, c and d), showing methods used and levels of accuracy. Notes on how the candidate checked methods and results.	• Calculations involving reacting masses. (2.3)

N2.3 INTERPRETING THE RESULTS OF CALCULATIONS			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context:** **(Topic No.)**
Interpret the results of calculations and present findings. The candidate must use at least **one** graph, **one** chart and **one** diagram.	• Select effective ways of presenting findings; • Present findings clearly, describing methods; and • Explain how the results of the calculations meet the purpose of the study.	Descriptions of findings and methods. Notes on how the results from the calculations met the purpose of the activity. At least **one** graph, **one** chart and **one** diagram presenting the findings.	• Half-life in radioactivity. (1.1) • Chemical Kinetics. (10)

APPLICATION OF NUMBER: LEVEL 3

Candidates must plan and carry through at least **one** substantial and complex activity that includes a number of **related** tasks for N3.1, N3.2 and N3.3. The AS/A Specification Topic Reaction Kinetics, 10.1, 23.1, is exemplified below.

N3.1 INTERPRET INFORMATION			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context:**
Plan and interpret information from **two** different sources, including a large data set.	• Plan how to obtain the information required to meet the purpose of the activity; • Obtain the relevant information; and • Choose appropriate methods for obtaining the results needed and justify the choice.	A description of the activity and tasks. Copies of source material, including a note of the large data set. A statement from someone who has checked the accuracy of any measurements or observations. Records and a justification of methods selected.	Plan, using e.g. textbooks/journals, and interpret information obtained in order to determine the effect of concentration on rate (AS)/the rate equation for a suitable reaction (A2). e.g. the reaction between hydrogen peroxide and iodide ions in acid solution. Work in pairs to investigate a particular reactant, and exchange data for other reactants to obtain a large data set. IT *could* be used in interfacing/data logging to obtain experimental data.

N3.2 CARRY OUT MULTI-STAGE CALCULATIONS			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context:**
Carry out multi-stage calculations to do with: a. amounts and sizes; b. scales and proportion; c. handling statistics; d. rearranging and using formulae.	• Carry out calculations to appropriate levels of accuracy, clearly showing methods; and • Check methods and results to help ensure errors are found and corrected.	Records of calculations (for a, b, c and d). Showing methods used and levels of accuracy. Notes on the large data set and how the methods and results were checked.	Calculate the rate of reaction at each concentration of a specific reactant. Obtain a large data set to include the rates of varying concentrations of each reactant.

N3.3 INTERPRETING THE RESULTS OF CALCULATIONS			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context:**
Interpret the results of calculations, present findings and justify methods. The candidate must use at least **one** graph, **one** chart and **one** diagram.	• Select appropriate methods of presentation and justify choice; • Present findings effectively; and • Explain how the results of the calculations relate to the purpose of the activity.	Report justifying methods and explanation of how results relate to the activity. At least **one** graph, **one** chart and **one** diagram.	Interpret the results and deduce the effects of concentration on rate (AS)/and write the rate equation for the investigated reaction (A2). Presentation of the findings *could* include the use of IT to produce graph(s), chart(s) and diagram(s).

INFORMATION TECHNOLOGY: LEVEL 1

IT 1.1 FIND, STORE AND DEVELOP INFORMATION			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context:** **(Topic No.)**
Find, explore and develop information for **two** different purposes.	• Find and select relevant information • Enter and bring in information, using formats that help development • Explore and develop information to meet the candidate's purpose.	Print-outs and copies of the information the candidate selects to use. A record from an assessor who observed the candidate using IT when exploring and developing information or working drafts with notes of how the candidate met the requirements of the Unit.	• Atomic structure. (1.1) • Data related to the physical properties of elements. (5.1.1) • Economic importance of alkane combustion. (8.1)

IT 1.2 PRESENT INFORMATION			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context:** **(Topic No.)**
Present information for **two** different purposes. The candidate's work must include **at least one** example of text, **one** example of images, and **one** example of numbers.	• Use appropriate layouts for presenting information in a consistent way • Develop the presentation so it is accurate, clear and meets the purpose • Save information so it can be found easily.	Working drafts showing how the candidate developed the presentation or records from an assessor who saw the student's screen displays. Print-outs or prints of a static or dynamic screen display of the candidates' final work, including examples of text, images and numbers. Records of how the candidate saved information.	• Atomic structure. (1.1) • Data related to the physical properties of elements. (5.1.1) • Economic importance of alkane combustion. (8.1)

INFORMATION TECHNOLOGY: LEVEL 2

IT 2.1 SEARCH FOR AND SELECT INFORMATION			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context:** **(Topic No.)**
Search for and select information for **two** different purposes.	• Identify the information needed and suitable sources • Carry out effective searches • Select information that is relevant to the candidate's purpose.	Print-outs of the relevant information with notes of sources and how the candidate made searches, or a record from an assessor who observed the student using IT when searching for information.	• Atomic structure. (1.1) • Data related to the physical properties of elements. (5.1.1) • Economic importance of alkane combustion. (8.1)

IT 2.2 EXPLORE AND DEVELOP INFORMATION			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context:** **(Topic No.)**
Explore and develop information, and derive new information, for **two** different purposes.	• Enter and bring together information using formats that help developments • Explore information as needed for the purpose • Develop information and derive new information as appropriate.	Print-outs, or a record from an assessor who observed the candidate using IT, with notes to show how the candidate explored and developed information and derived new information.	• Atomic structure. (1.1) • Data related to the physical properties of elements. (5.1.1) • Economic importance of alkane combustion. (8.1)

IT 2.3 PRESENT COMBINED INFORMATION			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context:** **(Topic No.)**
Present combined information for **two** different purposes. The candidate's work must include at least **one** example of text, **one** example of images and **one** example of numbers.	• Select and use appropriate layouts for presenting combined information in a consistent way • Develop the presentation to suit the purpose and the types of information • Ensure the work is accurate, clear and saved appropriately.	Working drafts, or a record from an assessor who observed the screen displays, with notes to show how the candidate developed content and presentation. Print-outs, or prints of static or dynamic screen displays, of the final work, including examples of text, images and numbers. Records of how the information was saved.	• Atomic structure. (1.1) • Data related to the physical properties of elements. (5.1.1) • Economic importance of alkane combustion. (8.1)

INFORMATION TECHNOLOGY: LEVEL 3

Candidates must plan and carry through at least **one** substantial activity that includes a number of related tasks for IT3.1, IT3.2 and IT3.3.

IT 3.1 SEARCH AND SELECT INFORMATION			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context: (Topic No.)**
Compare and use different sources to search for, and select, information required for **two** different purposes.	• Plan how to obtain and use information • Choose appropriate techniques for searches • Make selections based on judgements.	Print-outs with notes of sources and how searches made and selected information A record from someone who observed use of IT to search for and explore information.	Plan and use different databases, such as CD Roms and the Internet to search for and select information on **one** of the following: • The effect of physico-chemical principles on rate and yield in the Haber **and** Contact processes. (11.2) • The use of spectrometry to solve analytical problems in medicine **and** industry/environment. (12.4)

IT 3.2 DEVELOP INFORMATION			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context: (Topic No.)**
Explore, develop and exchange information and derive new information to meet **two** different purposes.	• Bring together information in consistent form • Create and use appropriate structures • Use methods for exchanging information.	Print-outs or record of someone who observed use of IT showing how information has been exchanged, explored and developed. Notes of automated routines	Explore, develop and exchange the information obtained in IT3.1 to derive new information to • Obtain the optimum conditions for the production of ammonia **and** sulphuric acid. (11.2) • Identify a suitable technique for the determination of drugs in medicine **and** heavy metal poisoning in industry/environment. (12.4)

IT 3.3 PRESENT INFORMATION			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context: (Topic No.)**
Present information from different sources for **two** different purposes and audiences. **One** example of text, **one** of images and **one** of numbers.	• Develop structures and content • Present information effectively • Ensure work is accurate.	Working drafts or a record from an assessor who observed screen displays, showing how developed for presentation. Print-outs or a static or dynamic screen display of final work, including text, images and numbers.	Present the information obtained from IT3.2 and IT3.3, to **two** different audiences, using Word Processing and Desk Top Publishing packages, importing into text a minimum of **one** chart and **one** set of numerical data. (11.2, 12.4)

WIDER KEY SKILLS

PROBLEM SOLVING: LEVEL 3

Candidates must provide at least **one** substantial example of meeting the standard of PS3.1, PS3.2 and PS3.3.

PS 3.1 EXPLORE PROBLEMS AND OPTIONS			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context: (Topic No.)**
Explore a complex problem, come up with **three** options for solving it and justify the options selected for taking it forward.	• 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 • Compare the main features of each possible option, including risk factors, and justify the option selected to take it forward.	Description of the problem, the analysis of its features and methods used for exploring it Statements endorsed by appropriate people of how problem was going to be solved Descriptions of the **three** options for solving the problem, with notes on the methods used for coming up with these and comparisons of their main features A note to justify the chosen option.	Explore one complex problem such as how to • find the enthalpy change of neutralisation of a 0.1M 'unknown' acid with 0.1M sodium hydroxide, coming up with **three** options, e.g. thermometric titration, 'standard' calorimetric technique, finding the pH to determine if tabulated strong acid - strong alkali datum is the required value. (6.2, 2.3) • analyse a mixture of solids, coming up with **three** options e.g. qualitative analysis, mass spectrometry, IR etc. (C/W, 12.4)

PS 3.2 PLAN AND IMPLEMENT OPTIONS			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context: (Topic No.)**
Plan and implement at least **one** option for solving a problem, review progress and revise approach as necessary**.**	• Plan how to carry out the chosen option and obtain agreement to go ahead from an appropriate person • Implement plan, effectively using support and feedback from others • Review progress towards solving the problem and revise approach as necessary.	A plan, with notes of changes made, and endorsed statement of how agreement to go ahead with chosen option was obtained Records of how plan is implemented, including how support and feedback was used and how progress was reviewed.	Plan and implement **one** method • for determining the enthalpy change of neutralisation (provided the acid is weak and unknown then tabulated data values are not feasible.) (6.2, 2.3) • of analysis e.g. qualitative. (C/W)

PS 3.3 CHECK AND REVIEW APPROACH			
Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**	**Suggested context: (Topic No.)**
Apply agreed methods to check if the problem has been solved, describe the results and review approach to problem solving.	• 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 • Review approach problem solving, including whether alternative methods and options might have proved more effective.	Description of the methods used, the results and conclusions Records of review, including notes of any alternative methods and options which might be predicted to have been more effective.	Check if the problem has been solved, describe the results and review whether alternative methods, • e.g. thermometric titration/ calorimetric technique (6.2, 2.3) • e.g. mass spectrometry/IR, if available (2.2, 12.4) might have proved more effective.

WORKING WITH OTHERS: LEVEL 3

Candidates must provide at least **one** substantial example of meeting the standard for WO3.1, WO3.2 and WO3.3 in both one-to-one and group situations.

WO 3.1 PLAN WORK

Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**
Plan complex work with others, agreeing objectives, responsibilities and working arrangements.	• 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 • Agree suitable working arrangements with those involved.	Reports which describe how the candidate planned work with others, including objectives, responsibilities, and working arrangements. Records from someone who observed the discussions with others or audio/video tape.

WO 3.2 WORK TOWARDS OBJECTIVES

Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**
Seek to establish & maintain cooperative working relationships over an extended period of time, agreeing changes to achieve agreed objectives.	• Organise and carry out tasks to show effectiveness and efficiency in meeting responsibilities and produce the quality of work required • Seek to establish and maintain cooperative working relationships, agreeing ways to overcome any difficulties • Exchange accurate information on progress of work, agreeing changes where necessary to achieve objectives.	Records of how the candidate organized and carried out tasks and maintained cooperative working relationships, including a progress report. These records could include a log, statements written by others with whom the candidate worked, audio/video tape recordings, photographs, or products made, with notes.

WO 3.3 REVIEW WORK

Candidates must:	**Evidence must show candidates can:**	**Examples of evidence:**
Review work with others and agree ways of improving collaborative work in the future.	• Agree the extent to which work with others has been successful and the objectives have been met • Identify factors that have influenced the outcomes • Agree ways of improving work with others in the future.	Statements (written or recorded) from both the candidate and others on the extent to which the agreed objectives were achieved. Reports produced with others on ways to improve future collaborate work.

Suggested context:
(Topic No.)

The following **contexts** could be used to generate evidence for WO3.1 and WO3.2 and WO3.3:

- investigations concerning e.g. Reaction Kinetics which require planning, collection and interpretation of large sets of data provide opportunities for situations involving both working in pairs and with groups. One such example, concerning the reaction between hydrogen peroxide and iodide ions in acid solution, is given under the Key Skill of Application of Number N3.1, N3.2, N3.3. (10.1, 23.1)

- collection of data from experimental results/databases to determine equilibrium concentration values that are then used to calculate K_c/K_p for some reactions e.g. ammonia/sulphur trioxide production, esterification, hydrolysis at different temperatures. The activity *could* be used to link to the Key Skill of Application of Number N3.2 and Information Technology IT3.1. (24.2)

- a presentation of the Petrochemical Industry. This *could* involve components such as fractional distillation, cracking, uses of related products, availability of resources and alternative energy sources.
  The activity *could* be used to link to the Key Skill of Communication C3.1, C3.2. (8.3)

IMPROVING OWN LEARNING AND PERFORMANCE: LEVEL 3

Candidates must provide at least **one** substantial example of meeting the standard for LP3.1, LP3.2 and LP3.3.

LP 3.1 AGREE TARGETS

Candidates must:	Evidence must show candidates can:	Examples of evidence:
Agree targets and plan how these will be met over an extended period of time, using support from appropriate people.	• Seek information on the ways to achieve what they want and identify factors that might affect plans • Use this information to agree realistic targets with appropriate people • Plan how time will be effectively managed and use support to meet targets, including alternative action for overcoming possible difficulties.	Records to show how the candidate obtained and used information to agree targets An action plan for an extended period of time (eg. about three months) including alternative courses of action and a note of support needed.

LP 3.2 USE A PLAN

Candidates must:	Evidence must show candidates can:	Examples of evidence:

• Take responsibility for learning by using plan, seeking feedback and support from relevant sources, to help meet targets
• Improve performance by:
  • studying a complex subject
  • learning through a complex practical activity
  • further study or practical activity involving independent learning.
	• Manage time effectively to complete tasks, revising plan if necessary
	• Seek and actively use feedback and support from relevant sources to meet targets
	• Select and use different ways of learning to improve performance, adapting approaches to meet new demands.
		A log of learning, with notes of:
		• how the candidate learned in different ways and adapted his/her approach
		• when the candidate sought feedback and support and how he/she used it
		• any revisions made to the plan
		Records from those who have seen the work managed effectively and tasks were completed.

LP 3.3 REVIEW PROGRESS AND ACHIEVEMENTS

Candidates must:	Evidence must show candidates can:	Examples of evidence:
Review progress on **two** occasions and establish evidence of achievement, including how learning from other tasks has been used to meet new demands.	• Provide information on the quality of learning and performance, including factors that have affected the outcome • Identify targets met, seek relevant sources to establish evidence of achievements • Exchange views with appropriate people to agree ways to further improve performance.	Records of information provided by the candidate on his/her learning and performance, including how he/she used learning from other tasks to meet new demands Examples of work which show what the candidate learned from studying complex subjects, through practical activity and independent learning Records of discussions which show how the candidate sought evidence of his/her achievements and exchanged views on ways to improve performance Note on action plan to show targets that have been met.

Suggested context: (Topic No.)

The following **contexts** could be used to generate evidence for LP3.1, LP3.2 and LP3.3.

- practical coursework related to AS/A topics† e.g. stoichiometry, thermochemistry, kinetics. (2, 6, 10, C/W)
- identification of unknown compounds: empirical formulae *could* be determined from elemental composition; deduction of molecular formulae using e.g. titration values, mass spectrometer values and gravimetric results. Structure elucidation *could* be performed as a practical activity. Infrared, ultraviolet-visible and nuclear magnetic resonance spectroscopy *could* be used to support structure elucidation. (7.4, 12.4, 23, 24, C/W)
- write a document on periodicity and the chemistry of the *s* & *p* blocks and transition elements. (5, 19, 20, 21, 22)