



## CCEA GCE Specification in Chemistry

For first teaching from September 2008

For first award of AS Level in Summer 2009

For first award of A Level in Summer 2010

Subject Code: 1110

# chemistry

## Foreword

This booklet contains CCEA's Advanced Subsidiary (AS) and Advanced GCE Chemistry specification for first teaching from September 2008.

The AS is the first part of the full advanced GCE course and will be assessed at a standard appropriate for students who have completed the first half of the full Advanced GCE course.

The full Advanced GCE comprises the AS and the second half of the Advanced GCE course referred to as A2. However, the AS can be taken as a "stand-alone" qualification without progression to A2.

The A2 will be assessed at a standard appropriate for students who have completed a full advanced GCE course and will include synoptic assessment and an element of stretch and challenge.

The Advanced GCE award will be based on aggregation of the marks from the AS (50%) and the A2 (50%).

An A\* will be awarded to the candidates who attain an overall grade A in the qualification and an aggregate of at least 90% of the uniform marks across the A2 units.

Subject Code	1110
QAN	500/2495/4
QAN	500/2494/2
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## 1 Introduction

This specification sets out the content and assessment details for our Advanced Subsidiary (AS) and Advanced Level (A Level) courses in Chemistry. This specification is for first teaching from September 2008. You can view and download the latest version of this specification from our website: [www.ccea.org.uk](http://www.ccea.org.uk).

Students can take the AS course as a final qualification or as the first half of the A Level qualification. Students who wish to obtain a full A Level qualification must also complete the second half of the course, which is referred to as A2. We will make the first AS awards for this specification in 2009 and will make the first A Level awards in 2010.

The specification builds on the broad objectives of the revised Northern Ireland Curriculum. It is also relevant to key curriculum concerns in England and Wales.

This specification promotes continuity, coherence and progression within the study of Chemistry.

The specification adheres to the 2006 Subject Criteria for AS and Advanced GCE Chemistry. It also conforms to the GCE Advanced Subsidiary and Advanced Level Examinations Qualification-Specific Criteria and Common Criteria established jointly by the regulatory authorities in England, Wales and Northern Ireland. The Qualifications and Curriculum Authority (QCA) publishes these criteria.

Chemistry is the study of elements and the compounds they form. The spiritual, moral, ethical, social and cultural issues arising from such study enables students to discuss and analyse Chemistry's contribution to society. This involves:

- a critical appraisal of the use of finite resources and the way in which they are used; and
- development of a global responsibility for ethical use of advances in Chemistry.

Students can use the Key Skill of Communication to explore these issues.

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

Students become aware of environmental and health and safety considerations through the following course content:

- Hydrocarbons
- Alcohols
- Equilibrium
- Kinetics
- Transition metals.

Questions using stimulus material exemplify European developments in environmental and health and safety considerations.

We have designed this specification to be as free as possible from ethnic, gender, religious, political or other forms of bias.

## 1.1 Aims

Students should be encouraged to:

- develop their interest in and enthusiasm for Chemistry, including developing an interest in further study and careers in the subject;
- appreciate how society makes decisions about scientific issues and how the sciences contribute to the success of the economy and society;
- develop and demonstrate a deeper appreciation of the skills, knowledge and understanding of how science works; and
- develop essential knowledge and understanding of different areas of the subject and how they relate to each other.

## 1.2 Key features

The specification's key features are as follows:

- There is less time spent on written examinations when compared to the previous specification.
- Less structured questions provide stretch and challenge.
- The specification provides a firm foundation for those wishing to enter higher education courses in Chemistry or related subjects such as medicine, dentistry and pharmacy. Entry to most of these courses is dependent on an A Level award in Chemistry.
- The specification content and also the contexts set in examination questions address contemporary Chemistry and its assessment.

## 1.3 Prior attainment

The AS builds on, but does not depend upon, the knowledge, understanding and skills developed within GCSE Science: Chemistry or GCSE Science: Double Award. The Advanced GCE specification incorporates the AS. The A2 section of the Advanced GCE builds upon the foundations of knowledge, understanding and skills developed within the AS.

## 1.4 Prohibited combinations

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

There is a national classification code assigned to every specification indicating the subject area to which it belongs. The classification code for this specification is 1110.

Centres should be aware of students who enter for more than one GCE qualification with the same classification code. They will have only one grade (the highest) counted for the purpose of the school and college performance tables.

## 2 Specification at a Glance

The tables below summarises the structures of the AS and A Level courses:

Unit	Assessment Format	Duration	Weightings	Availability
<b>AS 1: Basic Concepts in Physical and Inorganic Chemistry</b>	A written paper consisting of Section A, containing 10 multiple choice questions (20 marks), and Section B, containing a number of structured questions (80 marks). Externally assessed.	1 hour 30 minutes	35% of AS  17.5% of A Level	January and Summer
<b>AS 2: Further Physical and Inorganic Chemistry and Introduction to Organic Chemistry</b>	A written paper lasting consisting of Section A, containing 10 multiple choice questions (20 marks), and Section B, containing a number of structured questions (80 marks). Externally assessed.	1 hour 30 minutes	35% of AS  17.5% of A Level	January and Summer
<b>AS 3: Internal Assessment</b>	This unit is timetabled and taken by candidates under controlled conditions. The papers will be marked by the centres to a CCEA-supplied mark scheme.  Section A consists of two practical tasks (each worth 25 and 29 marks respectively). Section B has a planning exercise (20 marks) and a number of other questions testing knowledge of practical techniques, observations and calculations (16 marks). Internally assessed.	2 hours 30 minutes	30% of AS  15% of A Level	Summer only

Unit	Assessment Format	Duration	Weightings	Availability
<b>A2 1: Periodic Trends and Further Organic, Physical and Inorganic Chemistry</b>	A written paper consisting of Section A, containing 10 multiple choice questions (20 marks), and Section B, which has a number of structured questions (100 marks). Externally assessed.	2 hours	40% of A2  20% of A Level	January and Summer
<b>A2 2: Analytical, Transition Metals, Electrochemistry and Further Organic Chemistry</b>	A written paper consisting of Section A, containing 10 multiple choice questions (20 marks), and Section B, which has a number of structured questions (100 marks). Externally assessed.	2 hours	40% of A2  20% of A Level	Summer only
<b>A2 3: Internal Assessment</b>	This is a practical examination consisting of a planning exercise (20 marks) and practical exercises (50 marks). Internally assessed.	2 hours 30 minutes	20% of A2  10% of A Level	Summer only

### 3 Subject Content

The AS course is divided into three units: AS 1, AS 2 and AS 3. Students following the A Level course must study three further units: A2 1, A2 2 and A2 3. The content of each of these units is set out below:

#### 3.1 Unit AS 1: Basic Concepts in Physical and Inorganic Chemistry

This module contains units on atomic structure and bonding as well as the shapes adopted by molecules and ions and the intermolecular forces existing between them. There is a general introduction to the Periodic Table with an in-depth study of Group VII. Redox reactions are introduced while analytical chemistry consists of acid-base titrations. Basic calculations and equations are an integral unit of this module.

Content	Learning Outcomes
<b>1.1 Formulae, equations and amounts of substance</b>	<p>Students should be able to:</p> <p>1.1.1 write and balance equations for unfamiliar reactions when reactants and products are specified;</p> <p>1.1.2 write balanced equations (full and ionic) for all reactions studied;</p> <p>1.1.3 understand the concept of the mole in terms of Avogadro's number and molar mass as the mass of one mole of a substance;</p> <p>1.1.4 understand the concept of Avogadro's number (determination not required);</p> <p>1.1.5 calculate reacting masses of substances including examples in which some reactants are in excess;</p> <p>1.1.6 understand the terms anhydrous, hydrated and water of crystallisation and be able to calculate the moles of water of crystallisation present from experimental data;</p>
<b>1.2 Atomic structure</b>	<p><i>Note: any question, including those on bonding, asking for an electronic arrangement/ configuration/ structure should use spd notation (even if this is not specifically stated) and statements, showing an electron arrangement as 2.8.7 will not be credited.</i></p> <p>1.2.1 describe the properties of electrons, protons and neutrons in terms of their location in the atom and their relative masses and charges;</p> <p>1.2.2 explain the terms atomic number and mass number and use them to deduce the numbers of protons, neutrons and electrons in an atom or ion;</p> <p>1.2.3 define relative atomic mass and relative molecular mass and understand that they are measured relative to the carbon-12 standard;</p> <p>1.2.4 recall the meaning of the term isotope and the definition of relative isotopic mass;</p>

Content	Learning Outcomes
<b>1.2 Atomic structure (cont.)</b>	<p>Students should be able to:</p> <p>1.2.5 interpret mass spectra of elements by calculating relative atomic masses and determining isotopic abundances (details of the workings of the mass spectrometer are not required);</p> <p>1.2.6 deduce relative molecular mass from a molecular ion peak (limited to ions with single charges);</p> <p>1.2.7 deduce the electronic configuration of atoms and ions up to krypton in terms of main energy levels using the building up principle (s, p and d notation and electrons-in-boxes notation);</p> <p>1.2.8 describe the shape of s and p orbitals;</p> <p>1.2.9 recall the definitions of first and successive ionisation energies in terms of one mole of gaseous atoms or ions;</p> <p>1.2.10 explain the trend in ionisation energies of atoms down groups, and across periods in terms of nuclear charge, distance of outermost electron from the nucleus, shielding and stability of filled and half-filled shells;</p> <p>1.2.11 understand that graphs of first ionisation energies of elements up to krypton, and successive ionisation energies of an element provide evidence for the existence of the main energy levels and s, p and d orbitals;</p> <p>1.2.12 understand how the spectrum of atomic hydrogen arises and how it gives evidence for discrete energy levels;</p> <p>1.2.13 understand the term ground state and appreciate that transitions to/from <math>n = 1</math> are in the ultra violet region and to/from <math>n = 2</math> are in the visible region of the spectrum;</p> <p>1.2.14 understand that the convergence of lines may be interpreted as convergence of energy levels leading to a value for the ionisation energy;</p> <p>1.2.15 use the equation <math>E = hf</math>;</p> <p>1.2.16 use flame colours to identify the metal ions <math>\text{Li}^+</math>, <math>\text{Na}^+</math>, <math>\text{K}^+</math> (using blue glass), <math>\text{Ca}^{2+}</math>, <math>\text{Ba}^{2+}</math> and <math>\text{Cu}^{2+}</math>; understand that flame colours arise from electronic transitions within the cation;</p>
<b>1.3 Bonding and structure</b>	<p><i>Note: dot and cross diagrams are required to show only the outermost electrons and, where appropriate, charges should be included.</i></p> <p>1.3.1 understand that ionic bonding involves attraction between oppositely charged ions formed by electron transfer;</p> <p>1.3.2 describe, including the use of dot and cross diagrams, ionic bonding, restricted to elements in groups I, II, VI and VII, the ions of which have a noble gas structure;</p>

Content	Learning Outcomes
<b>1.3 Bonding and structure (cont.)</b>	<p>Students should be able to:</p> <p>1.3.3 describe in simple terms the lattice structure of sodium chloride;</p> <p>1.3.4 explain the characteristic physical properties of ionic compounds ie melting point, boiling point, electrical conductivity;</p> <p>1.3.5 describe, including the use of dot and cross diagrams, a covalent bond as a shared pair of electrons and understand that C<sub>2</sub>H<sub>2</sub>, N<sub>2</sub> and CO<sub>2</sub> have multiple bonds;</p> <p>1.3.6 define the octet rule and state its limitations eg in BeCl<sub>2</sub> and BF<sub>3</sub>;</p> <p>1.3.7 explain the characteristic physical properties of molecular covalent crystals eg Iodine, to include melting point, boiling point, electrical conductivity. See also section 1.5.1;</p> <p>1.3.8 describe the coordinate bond as a special case of the covalent bond, eg as in the ammonium ion NH<sub>4</sub><sup>+</sup>;</p> <p>1.3.9 understand that metallic bonding involves a lattice of positive ions surrounded by delocalised electrons;</p> <p>1.3.10 explain the typical physical properties associated with metals ie hardness, melting point, electrical conductivity;</p> <p>1.3.11 describe the giant covalent structures of graphite and diamond;</p> <p>1.3.12 explain the characteristic physical properties of graphite and diamond ie electrical conductivity, hardness, melting point and boiling point;</p> <p>1.3.13 understand that electronegativity is the ability of an atom to attract the bonding electrons in a covalent bond;</p> <p>1.3.14 recall the trend in electronegativity of simple elements across periods and down groups;</p> <p>1.3.15 explain that bond polarity may arise when covalently bonded atoms have different electronegativities;</p> <p>1.3.16 understand that polar bonds may or may not give rise to a molecule with a permanent dipole, eg CO<sub>2</sub>, H<sub>2</sub>O;</p>
<b>1.4 Shapes of molecules and ions</b>	<p>1.4.1 explain, in terms of electron pair repulsion theory the shapes, and bond angles of molecules and ions containing up to six pairs of electrons around the central atom such as BeCl<sub>2</sub>, BF<sub>3</sub>, CH<sub>4</sub>, NH<sub>3</sub>, H<sub>2</sub>O, CO<sub>2</sub>, SF<sub>6</sub> and NH<sub>4</sub><sup>+</sup>. (questions are not set on hybridisation of orbitals); and</p> <p>1.4.2 explain the departure of the bond angles in NH<sub>3</sub> and H<sub>2</sub>O from the predicted tetrahedral, in terms of the increasing repulsion between bonding pair-bonding pair, lone pair-bonding pair and lone pair-lone pair electrons.</p>

Content	Learning Outcomes
<b>1.5 Intermolecular forces</b>	Students should be able to: <ul style="list-style-type: none"> <li>1.5.1 describe intermolecular forces as van der Waals forces (viewed as attractions between induced dipoles), permanent dipole attractions and hydrogen bonding (between molecules containing either or both of the O-H and N-H bonds);</li> <li>1.5.2 understand the relationships between these attractive forces and physical properties, such as melting point, boiling point and solubility, of simple covalent molecular substances;</li> <li>1.5.3 explain the low density of ice compared to water due to hydrogen bonding in ice (3D diagram not required);</li> </ul>
<b>1.6 Redox</b>	<ul style="list-style-type: none"> <li>1.6.1 calculate the oxidation state for an element in a compound or ion;</li> <li>1.6.2 explain oxidation and reduction in terms of electron transfer and changes in oxidation state;</li> <li>1.6.3 write balanced redox equations from given half equations and for reactions where the reactants and products are specified (omitting spectator ions);</li> </ul>
<b>1.7 The Periodic Table</b>	<ul style="list-style-type: none"> <li>1.7.1 understand the organisation of elements in the Periodic Table according to their proton numbers and electronic structures and recall the meaning of the terms group and period;</li> <li>1.7.2 classify an element as belonging to the s, p or d block according to its position in the Periodic Table;</li> <li>1.7.3 explain the trends in physical properties across the period sodium to argon, limited to melting points, atomic radius, electrical conductivity and first ionisation energies;</li> </ul>
<b>1.8 Group VII (fluoride, chlorine, bromine and iodine)</b>	<p><i>Note: practical work restricted to chlorine, bromine and iodine and their compounds. Reactions of the elements illustrated by use of chlorine gas (or chlorine water), bromine water and aqueous iodine (in potassium iodide solution).</i></p> <ul style="list-style-type: none"> <li>1.8.1 explain the trends within the group, limited to colour, physical state, melting and boiling points, first ionisation energies, electronegativities, atomic radius, bond energies of halogen molecules and of hydrogen halides;</li> <li>1.8.2 describe the solubility of the halogens in water and non-aqueous solvents, eg hexane;</li> <li>1.8.3 describe the reactivity of the halogens with hydrogen, phosphorus and sodium;</li> </ul>

Content	Learning Outcomes
<b>1.8 Group VII (fluoride, chlorine, bromine and iodine) (cont.)</b>	Students should be able to: <ul style="list-style-type: none"> <li>1.8.4 describe the reaction of the halogens with cold, dilute and hot concentrated aqueous sodium hydroxide and be able to explain the disproportionation in these reactions;</li> <li>1.8.5 recall the reaction of chlorine with water;</li> <li>1.8.6 describe the displacement reactions of the halogens with other halides in solution;</li> <li>1.8.7 recall the reactions of the halogens with iron (II) and iron (III) ions as appropriate;</li> <li>1.8.8 understand the trend in thermal stability of hydrogen halides related to bond enthalpies;</li> <li>1.8.9 recall the relative strengths of the acids, HF, HCl, HBr and HI;</li> <li>1.8.10 understand the reactions of solid halides with concentrated sulphuric acid in relation to the relative reducing ability of the hydrogen halides/halide ions;</li> <li>1.8.11 use of <math>\text{Ag}^+</math> ions to distinguish between <math>\text{Cl}^-</math>, <math>\text{Br}^-</math> and <math>\text{I}^-</math> (followed by aqueous ammonia);</li> <li>1.8.12 have an appreciation of the debate between public health policy and practice and the rights of the individual in relation to the effects of fluoridation of public water supplies on dental health;</li> </ul>
<b>1.9 Titrations</b>	<p><i>Note: The practical aspects of titrations are required in the assessment of practical skills. Knowledge of the techniques of titrations is expected but it would be normal to assume that all apparatus would have been washed with distilled/deionised water. The description should include which reagent is placed in the burette, name of indicator (but no reason for choice of indicator), detection of endpoint and what should be observed, repetition for accuracy.</i></p> <ul style="list-style-type: none"> <li>1.9.1 carry out experimentally acid-base titrations involving strong acid/strong base, strong acid/weak base and weak acid/strong base, eg determination of the degree of hydration in a sample of sodium carbonate, analysis of vinegar;</li> <li>1.9.2 recall the names and colour changes of suitable indicators for these titrations;</li> <li>1.9.3 understand the method of back titration, eg to determine the purity of a Group II metal, oxide or carbonate;</li> <li>1.9.4 calculate concentrations and volumes for reactions in solutions for structured titration calculations; and</li> <li>1.9.5 be familiar with the units of concentration eg <math>\text{mol dm}^{-3}</math> or <math>\text{mole l}^{-1}</math> referred to as molarity, and <math>\text{g dm}^{-3}</math>.</li> </ul>

### 3.2 Unit AS 2: Further Physical and Inorganic Chemistry and Introduction to Organic Chemistry

Organic chemistry forms a major part of this unit with work on the chemistry of alkanes, alkenes, haloalkanes and alcohols. There is a qualitative introduction to equilibrium and kinetics while thermochemistry is covered in some depth. The analytical chemistry aspects are covered by IR spectroscopy and qualitative analysis. There is also further work on basic calculation.

Content	Learning Outcomes
<b>2.1 Formulae and amounts of a substance</b>	<p>Students should be able to:</p> <p>2.1.1 demonstrate an understanding of the terms empirical and molecular formula and the relationship between them;</p> <p>2.1.2 calculate the empirical and molecular formulae using data, giving composition by mass;</p> <p>2.1.3 understand the concept of molar gas volume;</p> <p>2.1.4 deduce reacting gas volumes from chemical equations;</p> <p>2.1.5 calculate the percentage yield of the product of a reaction;</p> <p>2.1.6 use percentage yield to determine the amount of reagent(s) needed for a reaction;</p> <p>2.1.7 understand the concept of atom economies;</p>
<b>2.2 Nomenclature and isomerism in organic compounds</b>	<p>2.2.1 understand the terms empirical, molecular and structural formulae, homologous series and functional groups;</p> <p>2.2.2 apply IUPAC rules to naming organic compounds with up to six carbon atoms and containing up to two of the functional groups relevant to this specification;</p> <p>2.2.3 describe and explain structural isomerism for aliphatic compounds containing up to six carbon atoms;</p> <p>2.2.4 understand that stereoisomers (geometrical) isomers exist (alkenes) in cis and trans (E-Z) forms due to the energy barrier to rotation in these compounds;</p>
<b>2.3 Hydrocarbons – alkanes</b>	<p>2.3.1 write the general formulae for alkanes, <math>C_nH_{2n+2}</math>;</p> <p>2.3.2 understand that alkanes are saturated hydrocarbons;</p> <p>2.3.3 recall the molecular and structural formulae for alkanes containing up to six carbon atoms;</p> <p>2.3.4 use IUPAC rules to name alkanes, including branched structures;</p> <p>2.3.5 explain, in terms of van der Waals' forces, the variation in boiling points;</p> <p>2.3.6 recall that crude petroleum is the source of alkanes and that they are obtained by fractional distillation (no details of plant required) and understand thermal cracking;</p> <p>2.3.7 describe the combustion of alkanes in a limited and plentiful supply of air;</p>

Content	Learning Outcomes
<b>2.3 Hydrocarbons – alkanes (cont.)</b>	Students should be able to:  2.3.8 describe the substitution reactions of alkanes by chlorine and by bromine; 2.3.9 explain how homolytic fission leads to the mechanism for the photochemical reaction between methane and chlorine viewed as free radical substitution; 2.3.10 discuss the environmental problems associated with spillage and the combustion of hydrocarbons; 2.3.11 a simple account of the role of catalytic converters in reducing the environmental damage due to vehicle emissions by facilitating the conversion of carbon monoxide to carbon dioxide, of unburnt hydrocarbons to carbon dioxide and water and of NO <sub>x</sub> to nitrogen; catalyst poisoning by lead (technical details of the construction of catalytic converters are not required);
<b>2.4 Hydrocarbons – alkenes</b>	2.4.1 write the general formula for alkenes, C <sub>n</sub> H <sub>2n</sub> ; 2.4.2 understand that alkenes are unsaturated hydrocarbons and that they decolourise bromine water; 2.4.3 recall the molecular and structural formulae for alkenes containing up to six carbon atoms; 2.4.4 use IUPAC rules to name alkenes containing up to two C = C bonds; 2.4.5 use sigma and pi bonds to explain the relative bond strength and relative bond length of the C = C bond; 2.4.6 know that the C = C is a centre of high electron density and use this to explain the difference in reactivity of alkanes and alkenes; 2.4.7 describe the catalytic hydrogenation of alkenes using finely divided nickel and its application to the hardening of oils (the detailed structure of the oil molecule is not required); 2.4.8 describe the reaction of Cl <sub>2</sub> , Br <sub>2</sub> , HCl and HBr with simple alkenes. (Markovnikoff's rule not required); 2.4.9 explain the mechanism of the reaction between HBr and ethene viewed as electrophilic addition. Understand the term heterolytic fission; and 2.4.10 describe the addition polymerisation of alkenes eg ethene and propene.

Content	Learning Outcomes
<b>2.5 Halogenoalkanes</b>	Students should be able to: <ul style="list-style-type: none"> <li>2.5.1 write the general formula for halogenoalkanes <math>C_nH_{2n+1}X</math>, where X is a halogen atom;</li> <li>2.5.2 recall the molecular and structural formulae of halogenoalkanes with up to two halogen atoms and up to six carbon atoms (refer to primary, secondary and tertiary structures);</li> <li>2.5.3 use IUPAC rules to name halogenoalkanes containing up to two halogen atoms and up to six carbon atoms;</li> <li>2.5.4 comment on the variation in boiling points of the halogenoalkane;</li> <li>2.5.5 describe the laboratory preparation of a halogenoalkane from the corresponding alcohol, with specific reference to refluxing, using a separating funnel, removal of acidic impurities, drying, simple distillation;</li> <li>2.5.6 describe the substitution reactions of halogenoalkanes with aqueous alkali, ammonia and cyanide ions;</li> <li>2.5.7 explain the mechanism for the reaction of primary and tertiary bromoalkanes with hydroxide ions viewed as nucleophilic substitution;</li> <li>2.5.8 compare the ease of hydrolysis of primary halogenoalkanes related to bond enthalpy and bond polarity;</li> <li>2.5.9 describe the elimination of hydrogen bromide from bromoethane using ethanolic potassium hydroxide;</li> </ul>
<b>2.6 Alcohols</b>	<ul style="list-style-type: none"> <li>2.6.1 write the general formulae for alcohols, <math>C_nH_{2n+1}OH</math>;</li> <li>2.6.2 recall the molecular and structural formulae of alcohols with up to six carbon atoms (refer to primary, secondary and tertiary structures);</li> <li>2.6.3 use IUPAC rules to name alcohols containing up to two hydroxyl groups and up to six carbon atoms;</li> <li>2.6.4 refer to the effect of hydrogen bonding on boiling point and miscibility with water;</li> <li>2.6.5 recall the preparation of alcohols from halogenoalkanes;</li> <li>2.6.6 recall the industrial production of ethanol from (i) the fermentation of sugars and from (ii) the reaction of steam with ethene in the presence of <math>H_3PO_4</math>;</li> </ul>

Content	Learning Outcomes
<b>2.6 Alcohols (cont.)</b>	Students should be able to:  2.6.7 describe the combustion of alcohols and their use as an alternative fuel; 2.6.8 describe the reaction of primary alcohols with sodium, hydrogen bromide, phosphorus pentachloride and thionyl chloride; 2.6.9 comment on the oxidation of alcohols using acidified potassium dichromate with reference to (a) the formation of aldehydes and carboxylic acids from primary alcohols and the isolation of each depending on reaction conditions (b) the formation of ketones from secondary alcohols (c) the resistance to oxidation of tertiary alcohols; 2.6.10 describe the esterification reactions of alcohols with carboxylic acids and with ethanoyl chloride; 2.6.11 prepare iodoform and know its use to distinguish between alcohols containing $\text{CH}_3\text{CH}(\text{OH})$ and other alcohols with specific reference to recrystallisation and melting points; 2.6.12 discuss the use of ethanol in alcoholic drinks and its use as a recreational drug which can have beneficial and harmful effects. The idea of safe limits of 'units' of alcohol;
<b>2.7 Infra-red spectroscopy</b>	2.7.1 understand that groups of atoms within a molecule absorb infra-red radiation at characteristic frequencies; 2.7.2 explain that the absorption of radiation arises from molecular vibrations; 2.7.3 use infra-red spectra to elucidate molecular structure by identifying functional groups using tables of characteristic wave numbers; 2.7.4 identify the presence of impurities present in a sample of a compound using infra-red spectra;
<b>2.8 Energetics</b>	2.8.1 understand that chemical reactions are accompanied by enthalpy changes (frequently heat) and that these may be endothermic or exothermic; 2.8.2 discuss the concept of enthalpy change, $\Delta H$ ; 2.8.3 explain the terms enthalpy of reaction and standard conditions with specific reference to combustion, formation and neutralisation; 2.8.4 recall experimental methods to determine enthalpy changes; 2.8.5 calculate enthalpy changes from experimental data including the use of $\Delta H = mc\Delta T$ ; 2.8.6 construct a simple enthalpy level diagram;

Content	Learning Outcomes
<b>2.8 Energetics (cont.)</b>	Students should be able to:  2.8.7 appreciate the principle of conservation of energy and construct simple enthalpy cycles; 2.8.8 state Hess's Law and use it to calculate enthalpy changes indirectly; 2.8.9 explain the concept of the average bond enthalpy of covalent bonds and use values of bond enthalpy to estimate the enthalpy change in reactions;
<b>2.9 Equilibrium</b>	2.9.1 appreciate that many chemical reactions are reversible; 2.9.2 understand the dynamic nature of the equilibrium state; 2.9.3 deduce the qualitative effects of changes of temperature, pressure, concentration and catalysts on the position of equilibrium for a closed homogeneous system; 2.9.4 describe and explain the conditions used in industrial processes such as the Haber process for the formation of ammonia and the Contact process for sulphuric acid; 2.9.5 discuss the importance of a compromise between equilibrium and reaction rate in the chemical industry;
<b>2.10 Kinetics</b>	2.10.1 state the factors which control the rate of a chemical reaction ie concentration, pressure, temperature, catalyst; 2.10.2 use the collision theory to qualitatively explain how these factors affect the reaction rate; 2.10.3 show a qualitative understanding of the Maxwell-Boltzmann distribution of molecular energies in gases and interpret curves for different temperatures; 2.10.4 understand the concept of activation energy and its relationship to the Maxwell-Boltzmann distribution; 2.10.5 know the function of a catalyst;
<b>2.11 Group II elements and their compounds (Mg to Ba)</b>	2.11.1 state why these are regarded as s-block elements; 2.11.2 recall and explain the trends within the group, limited to electronic configuration, atomic radius and first ionisation energy; 2.11.3 recall the trends in the reaction of the elements with oxygen, water and dilute acids; 2.11.4 describe the basic nature of the oxides and their reactions with water and dilute acids; 2.11.5 explain the thermal stability of the carbonates and hydroxides related to the charges and sizes of the cation; and 2.11.6 recall the solubility trend of the sulphates and hydroxides.

Content	Learning Outcomes
2.12 Qualitative analysis	<p>Students should be able to:</p> <p>2.12.1 use a chemical test for the gases H<sub>2</sub>, O<sub>2</sub>, Cl<sub>2</sub>, CO<sub>2</sub>, SO<sub>2</sub> (using acidified dichromate), HCl, NH<sub>3</sub>;</p> <p>2.12.2 use flame colours to identify the metal ions Li<sup>+</sup>, Na<sup>+</sup>, K<sup>+</sup> (using blue glass), Ca<sup>2+</sup>, Ba<sup>2+</sup>, and Cu<sup>2+</sup>;</p> <p>2.12.3 use Ba<sup>2+</sup> to test for SO<sub>4</sub><sup>2-</sup>; Mg<sup>2+</sup> to distinguish between HCO<sub>3</sub><sup>-</sup> and CO<sub>3</sub><sup>2-</sup>; Ag<sup>+</sup> to distinguish between Cl<sup>-</sup>, Br<sup>-</sup>, and I<sup>-</sup> (followed by aqueous ammonia); and</p> <p>2.12.4 use potassium chromate solution to test for Ba<sup>2+</sup>; aqueous ammonia to test for Cu<sup>2+</sup>; NaOH to test for NH<sub>4</sub><sup>+</sup>; NaOH to distinguish between Fe<sup>2+</sup> and Fe<sup>3+</sup>; use NaOH and aqueous ammonia to distinguish between Al<sup>3+</sup>, Mg<sup>2+</sup> and Zn<sup>2+</sup>. Use SCN<sup>-</sup> to identify Fe<sup>3+</sup>.</p>

### 3.3 Unit AS 3: Internal Assessment

This unit is timetabled and taken by candidates under controlled conditions. The papers will be marked by the centres to a CCEA-supplied mark scheme.

Section A consists of two practical tasks each worth 25 and 29 marks respectively. Section B has a planning exercise worth 20 marks and a number of other questions testing knowledge of practical techniques, observations and calculations worth 16 marks.

### 3.4 Unit A2 1: Periodic Trends and Further Organic, Physical and Inorganic Chemistry

Further development of equilibrium and kinetics is included in this module and there are also units on Lattice Enthalpy and Entropy. The study of organic chemistry is continued with units on isomerism, aldehydes and ketones, carboxylic acids and esters, fats and oils. Periodic Trends and environmental chemistry complete this module.

Content	Learning Outcomes
<b>4.1 Lattice Enthalpy</b>	<p>Students should be able to:</p> <p>4.1.1 explain and use the term lattice enthalpy. (Lattice enthalpy will be regarded as the enthalpy of lattice breaking);</p> <p>4.1.2 construct Born-Haber cycles and carry out associated calculations (eg the halides of Groups I and II);</p> <p>4.1.3 explain the enthalpy changes associated with the dissolving of ionic compounds in water and carry out associated calculations;</p>
<b>4.2 Enthalpy, entropy and free energy</b>	<p>4.2.1 calculate the standard enthalpy change (<math>\Delta H^\ominus</math>) in a chemical reaction using Hess's Law (Unit 2);</p> <p>4.2.2 explain that <math>\Delta H</math> is not sufficient to explain spontaneous change eg the endothermic reaction between eg ammonium carbonate with ethanoic acid;</p> <p>4.2.3 recall that the balance between entropy and enthalpy determines the feasibility of a reaction;</p> <p>4.2.4 recall that entropy (S) is a measure of disorder;</p> <p>4.2.5 calculate the standard entropy change (<math>\Delta S^\ominus</math>) in a chemical reaction using standard entropy data (<math>S^\ominus</math>);</p> <p>4.2.6 use the equation <math>\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus</math> to calculate standard free energy changes;</p> <p>4.2.7 recall that processes are spontaneous (feasible) when the free energy change is negative;</p> <p>4.2.8 recall that when the enthalpy change is negative and the entropy change is positive the process is feasible at all temperatures;</p> <p>4.2.9 recall that when the enthalpy change is positive and the entropy change is negative the process is not feasible at any temperature; and</p> <p>4.2.10 recall that when the enthalpy change and the entropy change have the same sign, the feasibility of the process depends on the temperature T. Use the equation <math>\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus</math> to calculate the temperature (in K) at which these processes start/cease to be feasible.</p>

Content	Learning Outcomes
<b>4.3 Kinetics</b>	<p>Students should be able to:</p> <p>4.3.1 use simple rate equations in the form: rate = <math>k[A]^x[B]^y</math> (where <math>x</math> and <math>y</math> are 0, 1 or 2);</p> <p>4.3.2 explain and use the terms: rate of reaction, order and rate constant;</p> <p>4.3.3 deduce simple rate equations from experimental data;</p> <p>4.3.4 deduce, from a concentration-time graph, the rate of a reaction;</p> <p>4.3.5 deduce, from a rate-concentration graph, the order with respect to a reactant;</p> <p>4.3.6 recall that there is a relationship between the rate equation and mechanism (limited to the alkaline hydrolysis of primary and tertiary alkyl halides);</p> <p>4.3.7 explain and use the term: rate determining step;</p> <p>4.3.8 suggest experimental methods suitable for the study of the rate of a reaction;</p> <p>4.3.9 explain, qualitatively, the effect of temperature on rate constants;</p> <p>4.3.10 recall that reactions with a large activation energy have a small rate constant (simple graphical interpretation in terms of molecular kinetic energies);</p>
<b>4.4 Equilibrium (including principles from Unit 2)</b>	<p>4.4.1 understand and use the terms: concentration, mole fraction and partial pressure;</p> <p>4.4.2 calculate equilibrium concentrations and partial pressures given suitable data (including values for <math>K_c</math> and <math>K_p</math>);</p> <p>4.4.3 deduce expressions for the equilibrium constants <math>K_c</math> and <math>K_p</math> from given chemical equations and calculate the numerical values of these quantities, with units, given suitable data (limited to homogeneous systems);</p> <p>4.4.4 relate the value of <math>K_c</math> to the extent of reaction;</p> <p>4.4.5 understand the qualitative effects of changes of temperature and pressure on the position of equilibrium and on the value of the equilibrium constant; and</p> <p>4.4.6 carry out simple calculations involving partition coefficients (<math>K_d</math>) including examples involving successive extractions.</p>

Content	Learning Outcomes
<b>4.5 Acid-base equilibria</b>	<p>Students should be able to:</p> <p>4.5.1 use the Brønsted-Lowry theory of acids and bases to describe proton transfer in acid-base equilibria (including the idea of conjugate acid-base pairs);</p> <p>4.5.2 understand the terms “strong” and “weak” as applied to acids and bases;</p> <p>4.5.3 define the terms: <math>K_w</math> and <math>K_a</math> and recall the associated units;</p> <p>4.5.4 define the terms: <math>pK_w</math> and <math>pK_a</math>;</p> <p>4.5.5 define the term: pH;</p> <p>4.5.6 carry out calculations involving pH for strong acids, strong bases and weak acids;</p> <p>4.5.7 explain the meaning of the term “buffer solution” and give a qualitative explanation of how buffer solutions work;</p> <p>4.5.8 calculate of pH of a buffer solution made from a weak monobasic acid and sodium hydroxide;</p> <p>4.5.9 recall how titration curves are determined by experiment;</p> <p>4.5.10 use titration curves to explain the choice of indicator;</p> <p>4.5.11 predict whether a salt solution would be acidic, alkaline or neutral based on relative strengths of the parent acid and base (qualitative treatment only);</p>
<b>4.6 Isomerism (incorporates examples from Unit 2)</b>	<p>4.6.1 recognise that structural isomerism can exist between molecules which belong to different families of compounds eg aldehydes/ketones and carboxylic acids/esters;</p> <p>4.6.2 recall that an asymmetric centre gives rise to optical isomers which exist as non-superimposable mirror images;</p> <p>4.6.3 draw 3D representations of optical isomers;</p> <p>4.6.4 recall that optical isomers rotate plane polarised light in opposite directions;</p> <p>4.6.5 explain the term: “optically active”; and</p> <p>4.6.6 explain why mixtures of optical isomers may be optically inactive.</p>

Content	Learning Outcomes
<b>4.7 Aldehydes and ketones</b>	<p>Students should be able to:</p> <p>4.7.1 write the general formula for simple aldehydes and ketones, <math>C_nH_{2n}O</math>;</p> <p>4.7.2 recall the molecular and structural formulae of simple aldehydes and ketones (including branched structures) with up to six carbon atoms in the main chain;</p> <p>4.7.3 use IUPAC rules to name simple aldehydes and ketones (including branched structures) with up to six carbon atoms in the main chain;</p> <p>4.7.4 explain the physical properties (boiling points and solubility) of simple aldehydes and ketones by making reference to intermolecular attractions;</p> <p>4.7.5 recall that simple aldehydes and ketones can be prepared from the corresponding primary or secondary alcohol;</p> <p>4.7.6 recall the reaction of simple aldehydes and ketones with hydrogen cyanide;</p> <p>4.7.7 describe the mechanism for the nucleophilic addition reaction of hydrogen cyanide and propanone;</p> <p>4.7.8 recall the reaction of simple aldehydes and ketones with 2, 4-dinitrophenylhydrazine;</p> <p>4.7.9 recall the laboratory preparation of 2, 4-dinitrophenylhydrazones for identification purposes with reference to recrystallisation and melting point determination;</p> <p>4.7.10 recall the fact that oxidation can be used to distinguish between aldehydes and ketones, using acidified dichromate, Fehling's solution and Tollen's reagent (Fehling's solution and Tollen's reagent viewed as <math>Cu^{2+}</math> and <math>Ag^+</math> respectively. Equations involving [O] are acceptable; and</p> <p>4.7.11 recall that aldehydes and ketones can be reduced using lithal (<math>LiAlH_4</math>). Equations involving [H] are acceptable.</p>

Content	Learning Outcomes
<b>4.8 Carboxylic acids</b>	<p>Students should be able to:</p> <p>4.8.1 write the general formula for simple carboxylic acids, <math>C_nH_{2n}O_2</math>;</p> <p>4.8.2 recall the molecular and structural formulae of simple carboxylic acids (including branched structures) with up to six carbon atoms in the main chain;</p> <p>4.8.3 use IUPAC rules to name simple carboxylic acids (including branched structures) with up to six carbon atoms in the main chain;</p> <p>4.8.4 explain the physical properties (boiling points and solubility) of simple carboxylic acids by making reference to intermolecular attractions;</p> <p>4.8.5 recall that carboxylic acids can be formed from primary alcohols and aldehydes;</p> <p>4.8.6 recall the preparation of an aqueous solution of the acid from the corresponding primary alcohol;</p> <p>4.8.7 recall that carboxylic acids (or their salts) can also be formed by acid or base catalysed hydrolysis of esters and nitriles;</p> <p>4.8.8 recall that carboxylic acids are weak acids;</p> <p>4.8.9 recall that carboxylic acids form salts with bases such as sodium carbonate, sodium hydroxide and ammonia;</p> <p>4.8.10 recall the reaction of carboxylic acids with alcohols, <math>PCl_5</math>, <math>SOCl_2</math> and <math>LiAlH_4</math>. Equations involving [H] are acceptable;</p>
<b>4.9 Esters, fats and oils</b>	<p>4.9.1 write the general formula for simple monoesters, <math>C_nH_{2n}O_2</math>;</p> <p>4.9.2 recall the molecular and structural formulae of simple monoesters;</p> <p>4.9.3 use IUPAC rules to name simple monoesters;</p> <p>4.9.4 explain the physical properties (boiling points and solubility) of simple monoesters by making reference to intermolecular attractions;</p> <p>4.9.5 recall that esters can be formed from alcohols using carboxylic acids or acyl chlorides;</p> <p>4.9.6 recall the laboratory preparation of a liquid ester from a carboxylic acid and an alcohol;</p> <p>4.9.7 recall the acid and base catalysed hydrolysis of esters;</p> <p>4.9.8 recall the structure of fats as esters of propane-1, 2, 3-triol (glycerol) and fatty acids;</p> <p>4.9.9 recall that oils and fats can be hardened by catalytic hydrogenation; and</p> <p>4.9.10 define the term “iodine value” and appreciate its significance in terms of structure.</p>

Content	Learning Outcomes
<b>4.9 Esters, fats and oils cont.</b>	Students should be able to: <ul style="list-style-type: none"> <li>4.9.11 recall the experimental determination of iodine values;</li> <li>4.9.12 calculate iodine values given appropriate experimental data;</li> <li>4.9.13 define the term “saponification value” and appreciate its significance in terms of structure;</li> <li>4.9.14 calculate saponification values given appropriate experimental data;</li> <li>4.9.15 appreciate the contribution of polyunsaturates and polysaturates to healthy/unhealthy diets;</li> </ul>
<b>4.10 Periodic trends</b>	<p><i>Recall the variation in the character of the oxides and chlorides across the third period, sodium to chlorine, as indicated:</i></p> <ul style="list-style-type: none"> <li>4.10.1 <b>oxides:</b> Na<sub>2</sub>O, MgO, Al<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>, P<sub>4</sub>O<sub>10</sub>, SO<sub>2</sub>, SO<sub>3</sub> and Cl<sub>2</sub>O<sub>7</sub> limited to formulae, type of bonding, structures (excluding that of P<sub>4</sub>O<sub>10</sub>), classification as acidic, basic or amphoteric and the reaction of the compounds with water (if any). Write equations for the reactions which occur between these oxides and given simple acids and bases; and</li> <li>4.10.2 <b>chlorides:</b> NaCl, MgCl<sub>2</sub>, Al<sub>2</sub>Cl<sub>6</sub> and PCl<sub>5</sub> limited to formulae, type of bonding, structures and the reaction of the compounds with water (if any).</li> </ul>

Content	Learning Outcomes
<p><b>4.11 Environmental chemistry (simple treatment only)</b></p> <p>Air pollution (emphasis on global warming)</p> <p>Pollution of water (emphasis on eutrophication)</p> <p>Waste disposal (emphasis on polymers)</p>	<p>Students should be able to:</p> <p>4.11.1 recall that the “greenhouse effect” of a gas (eg CO<sub>2</sub>) depends on its atmospheric concentration and its ability to absorb infra-red radiation;</p> <p>4.11.2 describe and explain how the concentration of carbon dioxide in the atmosphere depends on natural processes including photosynthesis, respiration and the solubility of the gas in surface waters;</p> <p>4.11.3 recall that combustion of non-renewable hydrocarbon fuels is causing an increase in the atmospheric concentration of carbon dioxide;</p> <p>4.11.4 recall strategies to control, reduce and manage the atmospheric concentration of carbon dioxide;</p> <p>4.11.5 recall that nitrates are a source of water pollution;</p> <p>4.11.6 recall that the use of fertilisers in agriculture can be a source of water pollution;</p> <p>4.11.7 describe the advantages and disadvantages of using artificial and natural fertilisers;</p> <p>4.11.8 recall strategies to control, reduce and manage water pollution;</p> <p>4.11.9 recall that solid domestic and industrial waste contains a high percentage of polymers;</p> <p>4.11.10 describe the advantages and disadvantages of landfill and waste incineration; and</p> <p>4.11.11 recall strategies to control, reduce and manage the amount of polymer waste (including recycling).</p>

### 3.5 Unit A2 2: Analytical, Transition Metals, Electrochemistry and Further Organic Chemistry

Analytical chemistry is developed through units on mass spectrometry, nmr spectroscopy, volumetric analysis, colorimetry and chromatography. The inorganic chemistry studied is based mainly on Transition metals with specific reference to Cr and V. Organic nitrogen compounds form the backbone of the work on organic chemistry with a final unit on polymer chemistry.

Content	Learning Outcomes
<b>5.1 Mass spectrometry</b>	<p>Students should be able to:</p> <p>5.1.1 recall the meaning of and to identify base peak, molecular ion peak, M + 1 peak and fragmentation ions in a mass spectrum;</p> <p>5.1.2 suggest formulae for the fragment ions in a given mass spectrum;</p> <p>5.1.3 distinguish between molecules of similar RMM using high resolution mass spectrometry and very accurate RAM;</p> <p>5.1.4 explain the reasons for linking mass spectrometry to GLC;</p>
<b>5.2 Nuclear magnetic resonance spectroscopy</b>	<p>5.2.1 understand the difference between low resolution and high resolution nmr spectra;</p> <p>5.2.2 understand the reasons for the use of TMS as a standard;</p> <p>5.2.3 recognise chemically equivalent hydrogen atoms (protons);</p> <p>5.2.4 understand that chemical shifts depend on the chemical environment of hydrogen atoms;</p> <p>5.2.5 use integration curves to determine the relative number of protons in different chemical environments;</p> <p>5.2.6 apply the n + 1 rule to analyse spin-spin splitting, limited to doublets, triplets and quartets where n is the number of hydrogen atoms on an adjacent carbon atom; and</p> <p>5.2.7 deduce a molecular structure from an nmr spectrum, limited to simple organic compounds.</p>

Content	Learning Outcomes
<b>5.3 Volumetric analysis</b>	Students should be able to:  5.3.1 titrate edta with magnesium and calcium ions using eriochrome black T; 5.3.2 titrate iodine with sodium thiosulphate ions using starch as an indicator and estimate oxidising agents such as hydrogen peroxide and iodate ions by their reactions with excess potassium iodide; 5.3.3 titrate acidified potassium manganate (VII) with iron (II) and other reducing agents; 5.3.4 deduce titration equations given the half equations for the oxidant and the reductant; 5.3.5 evaluate the techniques used in experimental activity and recognise the limitations of these;
<b>5.4 Colorimetry</b>	5.4.1 explain how colorimetry can be used to determine the formula of a coloured complex such as $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ and $[\text{Fe}(\text{SCN})(\text{H}_2\text{O})_5]^{2+}$ ;
<b>5.5 Chromatography</b>	5.5.1 describe and explain how paper (one-way and two-way), thin-layer (TLC) and gas-liquid chromatography (GLC) is carried out qualitatively; 5.5.2 explain the terms $R_f$ values, retention time, partition and adsorption as related to chromatography; 5.5.3 interpret GLC data in terms of the percentage composition of a mixture; and 5.5.4 interpret one-way and two-way paper and TLC chromatograms.

<b>Transition metals (from Ti to Cu, with specific reference to Cr and V)</b>	
<i>Note: this section concerns the transition metals of period 3, but the general principles are applicable to all transition metals.</i>	
<b>Content</b>	<b>Learning Outcomes</b>
<b>5.6 General properties</b>	<p>Students should be able to:</p> <p>5.6.1 recall that transition metals or their ions have an incomplete d-shell, variable oxidation states, catalytic activity, and form coloured complexes;</p> <p>5.6.2 deduce the electronic configuration of transition metals and their ions and explain their stabilities based on the filling of the sub-shells;</p>
<b>5.7 Complexes</b>	<p>5.7.1 understand that complexes consist of a central metal atom or ion surrounded by a number of ligands, defined as anions or molecules possessing lone pairs of electrons;</p> <p>5.7.2 explain that ligands are molecules or atoms that contain a lone pair which can be donated to a transition metal atom or ion;</p> <p>5.7.3 explain the meaning of and deduce coordination numbers in complexes;</p> <p>5.7.4 deduce the oxidation number of transition metals in complexes and use them to explain redox and disproportionation reactions;</p> <p>5.7.5 explain that ligands are molecules or atoms that contain a lone pair which can be donated to a transition metal atom or ion;</p> <p>5.7.6 understand the distinction between monodentate, eg Cl<sup>-</sup>, H<sub>2</sub>O, NH<sub>3</sub> bidentate, eg NH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>NH<sub>2</sub> (represented by en) and polydentate ligands (edta);</p> <p>5.7.7 explain the relative strengths of ligands and to demonstrate them experimentally;</p> <p>5.7.8 explain ligand replacement in terms of positive entropy changes, eg a bidentate ligand displacing two monodentate ligands;</p> <p>5.7.9 recall that transition metal ions usually form octahedral complexes with small ligands eg H<sub>2</sub>O, NH<sub>3</sub>;</p> <p>5.7.10 recall that transition metal ions usually form tetrahedral complexes with large ligands eg Cl<sup>-</sup>; and</p> <p>5.7.11 recall that platinum forms square planar complexes.</p>

Content	Learning Outcomes
<b>5.8 Oxidation states</b>	<p>Students should be able to:</p> <p>5.8.1 recall the colours of the aqueous complexes of <math>\text{Cr}^{3+}</math>, <math>\text{Cr(VI)}</math> <math>\text{Mn}^{2+}</math>, <math>\text{Fe}^{2+}</math>, <math>\text{Fe}^{3+}</math>, <math>\text{Co}^{2+}</math>, <math>\text{Ni}^{2+}</math>, <math>\text{Cu}^{2+}</math>, <math>\text{V}^{2+}</math>, <math>\text{V}^{3+}</math>, <math>\text{V(IV)}</math>, <math>\text{V(V)}</math>;</p> <p>5.8.2 use as qualitative detection tests the formation of precipitates of the hydroxides of <math>\text{Cr}^{3+}</math>, <math>\text{Mn}^{2+}</math>, <math>\text{Fe}^{2+}</math>, <math>\text{Fe}^{3+}</math>, <math>\text{Co}^{2+}</math>, <math>\text{Ni}^{2+}</math>, <math>\text{Cu}^{2+}</math> with <math>\text{NaOH(aq)}</math> and <math>\text{NH}_3(\text{aq})</math> and, where appropriate, their subsequent dissolution;</p> <p>5.8.3 recall the reduction of <math>\text{VO}^{2+}</math>, by zinc in the presence of acid, to form <math>\text{VO}^{2+}</math>, <math>\text{V}^{3+}</math> and <math>\text{V}^{2+}</math>;</p> <p>5.8.4 deduce, given appropriate <math>E^\ominus</math> values, reagents for the interconversion of vanadium between its oxidation state and to combine half-cells to give an overall equation for a reaction;</p> <p>5.8.5 prepare chrome alum by the reduction of potassium dichromate, and prepare potassium dichromate by the oxidation of a chromium (III) salt;</p>
<b>5.9 Catalytic behaviour</b>	<p>5.9.1 explain the use of transition metals as heterogeneous catalysts, based on mechanisms involving chemisorption; and</p> <p>5.9.2 recall the use of transition metals, such as nickel in the hydrogenation of <math>\text{C}=\text{C}</math> double bonds. platinum-rhodium in the oxidation of ammonia, iron in the formation of ammonia and vanadium pentoxide in the manufacture of sulphuric acid.</p>

Content	Learning Outcomes
<b>5.10 Applications of transition metal complexes</b>	<p>Students should be able to:</p> <p>5.10.1 recall the use and outline the mode of action of cisplatin as an anti-cancer drug;</p> <p>5.10.2 explain the role of iron (II) in haemoglobin in the transportation of oxygen in blood and the poisonous nature of carbon monoxide;</p> <p>5.10.3 explain the role of edta in sequestering calcium ions and thus preventing the clotting of blood and the softening of water;</p>
<b>5.11 Electrode potentials</b>	<p>5.11.1 appreciate that when two dissimilar metals connected by a wire are dipped into a conducting liquid, an electric current will flow in the wire;</p> <p>5.11.2 use e.m.f. measurements to construct a reactivity series;</p> <p>5.11.3 define standard electrode potential and explain the construction and significance of the hydrogen electrode;</p> <p>5.11.4 use tables of standard electrode potentials to predict feasibility and direction of reactions and to calculate the e.m.f.;</p>
<b>5.12 Arenes</b>	<p>5.12.1 explain the structure and shape of the benzene molecule with reference to delocalised <math>\pi</math> electrons;</p> <p>5.12.2 explain the reactivities of benzene and alkenes related to the relative stabilities of the pi electron systems, eg the resistance of benzene to addition of bromine compared with an alkene;</p> <p>5.12.3 explain the mechanism of the monohalogenation of benzene by bromine and a catalyst;</p> <p>5.12.4 explain the mechanism of the mononitration of benzene by concentrated <math>\text{HNO}_3</math> and concentrated <math>\text{H}_2\text{SO}_4</math> viewed as an overall electrophilic substitution by the addition of the nitronium ion and the elimination of a hydrogen ion; and</p> <p>5.12.5 prepare methyl 3-nitrobenzoate from methyl benzoate to illustrate nitration of the benzene ring.</p>

Content	Learning Outcomes
5.13 Amines	<p>Students should be able to:</p> <p>5.13.1 write the general formula for amines, <math>C_nH_{2n+1}NH_2</math>;</p> <p>5.13.2 recall the molecular and structural formulae of amines with up to six carbon atoms (refer to primary, secondary and tertiary structures);</p> <p>5.13.3 use IUPAC rules to name amines containing up to six carbon atoms;</p> <p>5.13.4 refer to the effect of hydrogen bonding on boiling point and miscibility with water;</p> <p>5.13.5 recall the formation of primary aliphatic amines by reduction of nitriles using <math>LiAlH_4</math> and by the reaction of ammonia with alkyl halides;</p> <p>5.13.6 explain the formation of phenylamine by reduction of nitrobenzene using tin and hydrochloric acid, to the phenylammonium salt (practical experience and details of the anion not required), followed by liberation of the free amine by addition of alkali;</p> <p>5.13.7 explain the effect of hydrogen bonding on the boiling point and solubility in water of amines;</p> <p>5.13.8 recall the formation of salts by the reaction of amines with mineral acids and the liberation of amines from their salts using alkali;</p> <p>5.13.9 explain the relative basic strengths of ammonia, primary aliphatic amines and phenylamine using the availability of the lone pair on the nitrogen atom;</p> <p>5.13.10 recall the reaction of amines with ethanoyl chloride and use this reaction to identify unknown amines;</p> <p>5.13.11 explain the reaction of ethylamine and phenylamine with nitrous acid and to compare the stability of the diazonium ions formed;</p> <p>5.13.12 explain the formation of benzene diazonium chloride from phenylamine and its conversion to phenol and to iodobenzene;</p> <p>5.13.13 recall the coupling of diazonium ions with phenol;</p> <p>5.13.14 recall the use of azo-compounds as dyestuffs and indicators; and</p> <p>5.13.15 explain the colour of compounds such as dyestuffs and indicators based on the extent of delocalisation of electrons leading to the closer proximity of electronic energy levels.</p>

Content	Learning Outcomes
<b>5.14 Amides</b>	<p>Students should be able to:</p> <p>5.14.1 write the general formula for amides, <math>RCONH_2</math> where R is an alkyl group;</p> <p>5.14.2 recall the molecular and structural formulae of amides with the R group containing up to five carbon atoms;</p> <p>5.14.3 use IUPAC rules to name amides containing up to six carbon atoms per R group present;</p> <p>5.14.4 recall the preparation of amides via the reaction of carboxylic acids with ammonia and the reaction of amines with acyl chlorides;</p> <p>5.14.5 recall the hydrolysis of amides with acids and alkalis;</p> <p>5.14.6 recall the dehydration of amides with phosphorus pentoxide to form nitriles;</p> <p>5.14.7 explain the basicity of amides relative to amines by referring to the delocalisation of the lone pair on the nitrogen atom;</p>
<b>5.15 Amino acids</b>	<p>5.15.1 recall the formulae of glycine and alanine;</p> <p>5.15.2 explain the optical activity of amino acids;</p> <p>5.15.3 explain the solubility of amino acids in water and their relatively high melting point;</p> <p>5.15.4 explain the formation of dipolar ions (zwitterions) from amino acid molecules;</p> <p>5.15.5 recall the reactions of amino acids with sodium carbonate, copper (II) sulphate and nitrous acid;</p> <p>5.15.6 recall the primary structure of a protein as a sequence of amino acids joined by peptide links;</p> <p>5.15.7 explain the secondary and tertiary structure of proteins;</p> <p>5.15.8 define enzymes as biological catalysts and use a lock and key mechanism to explain enzyme action;</p> <p>5.15.9 explain that an enzyme is a protein with an active site and provides a path of lower activation energy. Details of the mechanisms of enzyme catalysis are not expected; and</p> <p>5.15.10 explain the effect of pH and temperature on enzyme activity.</p>

Content	Learning Outcomes
<b>5.16 Polymer chemistry</b>	Students should be able to: <ul style="list-style-type: none"> <li>5.16.1 understand that addition polymers are formed from molecules containing C = C bonds and is able to draw polymer structures from monomers and vice versa;</li> <li>5.16.2 recall the reagents and conditions for the production of LD and HD polythene;</li> <li>5.16.3 relate the flexibility and softening temperature of LD and HD polythene to branching and crystallinity;</li> <li>5.16.4 recall that polythene is chemically inert, its non-biodegradability leading to the need to develop waste management strategies including land fill and incineration;</li> <li>5.16.5 understand that condensation polymers are formed from molecules containing COOH, OH and NH<sub>2</sub> groups and be able to draw polymer structures from monomers and vice versa;</li> <li>5.16.6 understand the formation, structure and uses of the polyester, polyethylene terephthalate;</li> <li>5.16.7 understand the formation, structure and uses of the polyamide, nylon; and</li> <li>5.16.8 recall that polyesters and polyamides can be hydrolysed and thus are biodegradable.</li> </ul>

### 3.6 Unit A2 3: Internal Assessment

This is a practical examination consisting of a planning exercise (20 marks) and practical exercises (50 marks). This is internally assessed.

## 4 Scheme of Assessment

### 4.1 Assessment opportunities

Students can choose to be assessed in stages during their AS and A Level courses or leave all assessment to the end of these courses. Section 2 shows the availability of assessment units for the specification.

Students can choose to resit AS and A2 assessment units. The best result for each assessment unit will count towards the AS and A Level qualifications.

Results for each assessment unit can continue to contribute to an AS or A Level qualification while the specification is on offer.

### 4.2 Assessment objectives

The specification's assessment objectives are as follows:

#### **AO1: Knowledge and understanding of Chemistry and of how Chemistry works**

Students should be able to:

- recognise, recall and show understanding of scientific knowledge; and
- select, organise and communicate relevant information in a variety of forms.

#### **AO2: Application of knowledge and understanding of Chemistry and of how Chemistry works**

Students should be able to:

- analyse and evaluate scientific knowledge and processes;
- apply scientific knowledge and processes to unfamiliar situations including those related to issues; and
- assess the validity, reliability and credibility of scientific information.

#### **AO3: How Chemistry works**

Students should be able to:

- demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods;
- make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy; and
- analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in various ways.

### 4.3 Assessment objective weightings

The table below sets out the assessment objective weightings for each assessment unit and the overall AS and A Level qualifications. The actual percentages in the operational paper may cover a range conforming to those set out in the Science Criteria.

Assessment Objective	Assessment Unit					
	AS1	AS2	AS3	A21	A22	A23
AO1	42.5%	42.5%	20.0%	35.0%	35.0%	20.0%
AO2	42.5%	42.5%	20.0%	50.0%	50.0%	20.0%
AO3	15.0%	15.0%	60.0%	15.0%	15.0%	60.0%

Assessment Objective	Overall Weightings	
	AS	A2
AO1	35.0%	30.0%
AO2	35.0%	40.0%
AO3	30.0%	30.0%

Assessment Objective	A Level Award
AO1	32.5%
AO2	37.5%
AO3	30.0%

### 4.4 Quality of written communication

Assessment in AS and A Level qualifications in Chemistry requires students to demonstrate their quality of written communication. In particular, students must:

- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
- select and use a form and style of writing appropriate to their purpose and to complex subject matter; and
- organise information clearly and coherently, using specialist vocabulary where appropriate.

Examiners assess the quality of students' written communication in their responses to questions or tasks that require extended writing. In Chemistry, the examiners assess students' quality of written material in each unit except AS 3.

## 4.5 Synoptic assessment

The A2 assessment units include an element of synoptic assessment. This allows students to demonstrate expertise in the essential knowledge, understanding and skills of Chemistry.

In GCE Chemistry, synoptic assessment requires students to make and use connections within and between different areas of the subject at AS and A2, for example by:

- applying knowledge and understanding of more than one area to a particular situation or context;
- using knowledge and understanding of principles and concepts in planning experimental and investigative work and in the analysis and evaluation of data; and
- bringing together scientific knowledge and understanding from different areas of the subject and applying them.

## 4.6 Stretch and challenge

The A2 assessment units will include opportunities for stretch and challenge. This will be achieved by:

- including questions constructed with a deliberate incline of difficulty and a decrease in structuring;
- using of a variety of stems in questions to elicit a full range of response types;
- ensuring connectivity between sections of questions;
- providing opportunities for extended writing;
- using a wide range of question types to address different skills; and
- using synoptic assessment.

## 4.7 Reporting and grading

We report the results of individual assessment units on a uniform mark scale that reflects the assessment weighting of each unit.

AS qualifications are awarded on a five grade scale from A to E with A being the highest. A Level qualifications are awarded on a six grade scale from A\* to E with A\* being the highest. We determine the AS and A Level grades awarded by aggregating the uniform marks obtained on individual assessment units. To be awarded an A\*, candidates will need to achieve a grade A on their full A level qualification and an A\* on the aggregate of their A2 units. For students who fail to attain a grade E, we report their results as unclassified (U).

The grades we award match the performance descriptions published by the regulatory authorities (see Section 6.4).

## 5 Guidance on Internal Assessment

### 5.1 Setting of tasks

We set the assessment units, but teachers mark the units internally.

AS 3 is a practical examination which takes place in May. The practical exercises test students' skills of manipulation, measuring, recording and planning.

A2 3 is a practical examination and takes place in May. The practical exercises test students' skills of manipulation, measuring, recording, concluding and communicating.

### 5.2 Supervision of students

During the practical examinations, you must supervise pupils and ensure that the examinations meet all health and safety regulation requirements.

### 5.3 Marking of candidates' scripts

This will be carried out by centres using a CCEA-provided mark scheme.

## 6 Links

### 6.1 Support materials

We currently provide the following materials to support this specification:

- specimen papers;
- mark schemes; and
- a resource list.

We will expand our range of support materials through a coordinated science programme to include:

- support days for teachers;
- launch events; and
- a microsite.

You can find details of our Annual Support Programme of events and materials for Chemistry on our website: [www.ccea.org.uk](http://www.ccea.org.uk).

### 6.2 Curriculum objectives

This specification enables students to:

- discuss and analyse the contribution of chemistry to society in the spiritual, moral, ethical, social and cultural contexts that the specification provides;
- study elements and the compounds they form; and
- gain a prerequisite qualification for entry to higher education.

The spiritual, moral ethical, social and cultural issues which arise from this study will provide the opportunity for students to discuss and analyse the contribution of chemistry to society. This will involve a critical appraisal of the use of finite resources, the way in which they are used, and development of a global responsibility for ethical use of advances in chemistry.

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

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

- 1.8.11 Fluoridation
- 2.3 Hydrocarbons
- 2.6 Alcohols
- 2.9 Equilibrium
- 2.10 Kinetics
- 3.11 Environmental chemistry
- 4.6-4.10 Transition metals.

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

## 6.3 Key skills

This specification provides opportunities for students to develop and generate evidence for assessing the following skills:

- Communication (C3.1a, C3.1b, C3.2, C3.3 – Units 1, 2, 4, 5);
- Information and Communication Technology (IT3.1, IT3.2, IT3.3 – Units 1, 2, 4, 5);
- Application of Number (N3.1, N3.2, N3.3 – Units 1, 2, 4, 5);
- Working with Others (WO3.1, WO3.2, WO3.3 – Units 1, 2, 4, 5);
- Improving Own Learning and Performance (LP3.1, LP3.2, LP3.3 – Units 1, 2, 4, 5); and
- Problem-Solving (PS3.1, PS3.2, PS3.3 – Units 1, 2, 4, 5).

You can find details of the current standards and guidance for each of these skills on the QCA website: [www.qca.org.uk](http://www.qca.org.uk).

## 6.4 Performance descriptions

You can obtain performance descriptions for the AS and A2 judgemental A/B and E/U boundaries from the QCA website at [www.qca.org.uk](http://www.qca.org.uk).

## 6.5 Examination entries

The following entry codes apply to individual assessment units and the overall AS and A Level cash-ins in Chemistry:

AS 1:	AAC11
AS 2:	AAC12
AS 3:	AAC13
AS cash-in:	S1112
A2 1:	AAC21
A2 2:	AAC22
AAC23:	AAC23
A Level cash-in:	A1112

You can view details of how to make entries on our website. Alternatively, you can contact our Examination Entries, Results and Certification using the details provided in Section 6.8.

## 6.6 Students with particular requirements

We have designed this specification to minimise the need to adjust the assessment of students who have particular requirements. Details of the arrangements you can make for such students are available in the Joint Council for Qualifications document *Access Arrangements and Special Consideration: Regulations and Guidance Relating to Candidates Who Are Eligible for Adjustments in Examinations*.

## 6.7 Disability Discrimination Act (DDA)

AS/A Levels often require assessment of a broad range of competences. This is because they are general qualifications and, as such, prepare candidates for a wide range of occupations and higher level courses.

The revised AS/A Level qualification and subject criteria were reviewed to identify whether any of the competences required by the subject presented a potential barrier to any disabled candidates. If this was the case, the situation was reviewed again to ensure that such competences were included only where essential to the subject. The findings of this process were discussed with disability groups and with disabled people.

Reasonable adjustments are made for disabled candidates in order to enable them to access the assessments. For this reason, very few candidates will have a complete barrier to any part of the assessment. Information on reasonable adjustments is found in the Joint Council for Qualifications document *Access Arrangements and Special Consideration: Regulations and Guidance Relating to Candidates Who are Eligible for Adjustments in Examinations*.

Candidates who are still unable to access a significant part of the assessment, even after exploring all possibilities through reasonable adjustments, may still be able to receive an award. They would be given a grade on the parts of the assessment they have taken and there would be an indication on their certificate that not all of the competences have been addressed. *This will be kept under review and may be amended in the future.*

In A Level Chemistry practical assistants may be used for manipulating equipment and making observations. Technology may help visually impaired students to take readings and make observations.

## 6.8 Contact details

The following list provides contact details for relevant members of our staff:

- Specification Support Officer: Catriona Skelton  
(telephone: (028) 9026 1200, extension 2292, email: [cskelton@ccea.org.uk](mailto:cskelton@ccea.org.uk))
- Officer with Subject Responsibility: Robert Maguire  
(telephone: (028) 9026 1200, email: [rmaguire@ccea.org.uk](mailto:rmaguire@ccea.org.uk))
- Examination Entries, Results and Certification: Philip Macauley  
(telephone: (028) 9026 1262, email: [pmcauley@ccea.org.uk](mailto:pmcauley@ccea.org.uk))
- Examiner Recruitment  
(telephone: (028) 9026 1243, email: [appointments@ccea.org.uk](mailto:appointments@ccea.org.uk))
- Distribution (past papers and support materials)  
(telephone: (028) 9026 1242, email: [smurray@ccea.org.uk](mailto:smurray@ccea.org.uk))
- Support Events Administration: Events Information Service  
(telephone: (028) 9026 1401, email: [events@ccea.org.uk](mailto:events@ccea.org.uk))
- Information Section (including Freedom of Information requests)  
(telephone: (028) 9026 1200, email: [info@ccea.org.uk](mailto:info@ccea.org.uk))
- Business Assurance (appeals): Jeffrey Hamilton  
(telephone: (028) 9026 1205, email: [jhamilton@ccea.org.uk](mailto:jhamilton@ccea.org.uk)).



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