OCR
RECOGNISING ACHIEVEMENT

AS/A Level GCE

GCE Chemistry B (Salters)

OCR Advanced Subsidiary GCE in Chemistry B (Salters) H035

OCR Advanced GCE in Chemistry B (Salters) H435

version 3 – September 2013

specification

QAN 500/2256/8
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Contents

Contents

Vertical black lines indicate a significant change to the previous printed version.

1 About these Qualifications

This booklet contains OCR's Advanced Subsidiary (AS) GCE and Advanced GCE specifications in Chemistry B (Salters) for teaching from September 2013.

Chemistry B (Salters) was first examined in 1992 as a new concept project examination. In contrast to the traditional 'topic-based' approach, Chemistry B (Salters) is 'context-led'. Chemical concepts are introduced within a relevant context, the course being written as a series of teaching modules based on contemporary issues in chemistry. Students study the chemistry in a spiral way so that chemical ideas, introduced in an early topic, are reinforced later. The 'drip-feed' approach to teaching and learning chemical principles allows candidates to revisit a particular topic several times during the course, each time taking their knowledge and understanding a step further. Each assessment unit contains a variety of chemical ideas, as dictated by the teaching modules, and this forms the basis for the specification. As the candidates have been accustomed to learning their chemistry in context, the examination questions are also set in context.

These specifications are fully supported by course materials written and developed by the University of York Science Education Group in collaboration with OCR and with sponsorship from The Salters' Institute of Industrial Chemistry.

1.1 The Three-Unit AS

The AS GCE is both a 'stand-alone' qualification and also the first half of the corresponding Advanced GCE. The AS GCE is assessed at a standard appropriate for candidates who have completed the first year of study (both in terms of teaching time and content) of the corresponding two-year Advanced GCE course, ie between GCSE and Advanced GCE.

From September 2013 the AS GCE is made up of **three** mandatory units, of which **two** are externally assessed and **one** is internally assessed and will include the assessment of practical skills. These units form 50% of the corresponding six-unit Advanced GCE.

1.2 The Six-Unit Advanced GCE

From September 2013 the Advanced GCE is made up of **three** mandatory units at AS and **three** further mandatory units at A2.

Two of the AS and **two** of the A2 units are externally assessed.

The third AS unit and the third A2 unit are internally assessed and will include the assessment of practical skills.

1.3 Qualification Titles and Levels

These qualifications are shown on a certificate as:

- OCR Advanced Subsidiary GCE in Chemistry.
- OCR Advanced GCE in Chemistry.

Both qualifications are Level 3 in the National Qualifications Framework (NQF).

1.4 Aims

The aims of these specifications are to encourage candidates to:

- develop their interest in, and enthusiasm for chemistry, including developing an interest in further study and careers in chemistry;
- 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*;
- develop essential knowledge and understanding of different areas of chemistry and how they relate to each other.

1.5 Prior Learning/Attainment

These specifications have been developed for students who wish to continue with a study of chemistry at Level 3 in the National Qualifications Framework (NQF). The AS specification has been written to provide progression from GCSE Science and GCSE Additional Science, or from GCSE Chemistry; achievement at a minimum of grade C in these qualifications should be seen as the normal requisite for entry to AS Chemistry. However, students who have successfully taken other Level 2 qualifications in Science or Applied Science with appropriate chemistry content may also have acquired sufficient knowledge and understanding to begin the AS Chemistry course. Other students without formal qualifications may have acquired sufficient knowledge of chemistry to enable progression onto the course.

Recommended prior learning for the AS units is shown in the introduction to each AS unit. The A2 units build upon the knowledge and understanding acquired at AS.

Recommended prior learning for the A2 course is successful performance at AS Chemistry.

2 Summary of Content

2.1 AS Units

Unit F331: *Chemistry for Life*

- Elements of Life;
- Developing Fuels.

Unit F332: *Chemistry of Natural Resources*

- Elements from the Sea;
- The Atmosphere;
- Polymer Revolution.

Unit F333: *Chemistry in Practice*

This AS (practical skills) unit is teacher assessed and externally moderated by OCR. Candidates are assessed in **five** skill areas: competence, measurement, analysis and evaluation, observation, and interpretation. Also see Appendix B.

2.2 A2 Units

Unit F334: *Chemistry of Materials*

- What's in a Medicine?;
- The Materials Revolution;
- The Thread of Life;
- The Steel Story.

Unit F335: *Chemistry by Design*

- Agriculture and Industry;
- Colour by Design;
- The Oceans;
- Medicines by Design.

Unit F336: *Chemistry Individual Investigation*

This A2 (practical skills) unit is teacher assessed and externally moderated by OCR. Candidates carry out a single individual investigation. The topic may be taken from any aspect of chemistry. Also see Appendix B.

3 Unit Content

3.1 AS Unit F331: *Chemistry for Life*

This unit covers the following teaching modules:

- (**EL**) Elements of Life;
- (**DF**) Developing Fuels.

Candidates are expected to apply knowledge, understanding and other skills gained in this unit to new situations and/or to solve related problems.

Recommended prior knowledge

Candidates should:

- have achieved Grade C or above in both GCSE Science and GCSE Additional Science, or GCSE Chemistry, or an equivalent standard in other appropriate Level 2 qualifications.

(**EL**) Elements of Life

A study of elements and compounds in the universe, the solar system and the human body.

The chemical ideas in this module are:

- atomic structure;
- radioactivity: fission and fusion;
- chemical equations and amount of substance;
- the Periodic Table and Group 2 chemistry;
- bonding and the shapes of molecules.

How Science Works

Aspects from the list in Appendix C studied in this module include:

i. development of models (illustrated by the theories of the atom), development of Mendeleev's ideas of the Periodic Table and limitations of '*dot-and-cross*' diagrams;
vii. development of models (eg atomic theory) and Mendeleev's ideas show the tentative nature of scientific knowledge;
ix. benefits and risks of radioactive tracers;
xi. the scientific community validating Mendeleev's work on the Periodic Table.

Links

The following is assumed knowledge from Key Stage 4:

- chemical change takes place by the rearrangement of atoms in substances;
- new materials are made from natural resources by chemical reactions;
- there are patterns in the chemical reactions between substances;
- structure and bonding (Additional Science).

The following topics in this teaching module are also treated in other teaching modules:

- amount of substance (**DF** and **ES** and many others);
- the electronic structure of atoms (**ES**, **SS**);
- the Periodic Table (**ES**, **SS** and **AA**);
- shapes of molecules (**DF**, **PR**, **EP**, **MD**);
- atomic emission spectroscopy (**CD**).

Topic	Assessable learning outcomes
Formulae, equations and amount of substance	Candidates should be able to: (a) explain and use the terms: *atomic number*, *mass number*, *isotope*, *Avogadro constant*, *relative isotopic mass*, *relative atomic mass*, *relative formula mass* and *relative molecular mass*; (b) use the concept of amount of substance to perform calculations involving: masses of substances, empirical and molecular formulae, percentage composition; (c) write and interpret balanced chemical equations including state symbols;
Atomic structure	(d) describe protons, neutrons and electrons in terms of their mass and relative charge; (e) describe the structure of atoms in terms of electrons and a central nucleus containing protons and neutrons; (f) explain the occurrence of absorption and emission atomic spectra in terms of changes in electronic energy levels; compare and contrast the features of these spectra: (i) similarities: both line spectra; lines in same position for a given element; lines become closer at higher frequencies; sets of lines representing transitions to or from a particular level, (ii) differences: bright/coloured lines on a black background or black lines on coloured/bright background; understand the relationship between the energy emitted or absorbed and the frequency of the line produced in the spectra; $\Delta E = h\nu$; (g) describe the electron structure of atoms in terms of main energy levels (electron shells), up to Z = 36; (h) recall that the nuclei of some atoms are unstable and that these atoms are radioactive; recall and explain the different properties of α-, β- and γ-radiations; recall that the term *half-life* refers to the time taken for half the radioactive nuclei in a sample to decay and that the half-life is fixed for any given isotope; carry out half-life calculations; (i) use nuclear symbols to write equations for nuclear processes, both fusion and radioactive decay; (j) recall that, in fusion reactions, lighter atoms join to give heavier atoms (under conditions of high temperature and pressure) and understand that this is how certain elements are formed;

	(k) understand how radioactive isotopes can be used as 'tracers' in the body and (given information) for other uses; explain that the half-life of 'tracers' must be of an appropriate length to allow detection but not cause undue damage; understand the use of radioisotopes in the dating of archaeological and geological material; (l) understand that knowledge of the structure of the atom developed in terms of a succession of gradually more sophisticated models; given information, interpret these and other examples of such developing models;
Bonding and structure	(m) draw and interpret simple electron '*dot-and-cross*' diagrams to show how atoms bond through ionic, covalent and dative covalent bonds and be able to describe a simple model of metallic bonding; describe some limitations of these models; (n) recall the typical physical properties (melting point, solubility in water, ability to conduct electricity) characteristic of giant lattice (metallic, ionic, covalent network) and simple molecular structure types; (o) use the electron pair repulsion principle to predict and explain the shapes of simple molecules (such as CH_4, NH_3, H_2O and SF_6) and ions (such as NH_4^+) with up to six outer pairs of electrons (any combination of bonding pairs and lone pairs) (no treatment of hybridisation or molecular orbitals is expected);
Inorganic chemistry and the Periodic Table	(p) recall that the Periodic Table lists elements in order of atomic (proton) number and groups elements together according to their common properties; use given information to describe trends in a group of the Periodic Table and to make predictions concerning the properties of an element in this group; describe periodic trends in the properties of elements, in terms of melting point and boiling point; (q) recall that the position of an element in the Periodic Table is related to its electron structure (main energy levels or electron shells) and *vice versa*; (r) describe and compare the following properties of the elements and compounds of Mg, Ca, Sr and Ba in Group 2: reactions of the elements with water, acid–base character of the oxides and hydroxides, thermal stability of the carbonates, solubilities of hydroxides and carbonates; (s) understand how Mendeleev developed the Periodic Table by leaving gaps and rearranging some elements from their atomic mass order and how subsequent research validated this knowledge; given relevant information, discuss other examples of how scientific research can be used to assess the validity of a discovery;

Modern analytical techniques	(t) describe and explain the main stages in the operation of a time-of-flight mass spectrometer; (u) use data from a mass spectrometer to: (i) calculate relative atomic mass and the relative abundance of isotopes, (ii) work out the relative molecular mass of molecules and understand that other peaks are caused by fragments of the molecule (no detail required at this stage).

(**DF**) Developing Fuels

A study of fuels and the contribution that chemists make to the development of better fuels.

The chemical ideas in this module are:

- thermochemistry;
- organic chemistry: alkanes, structural isomers;
- introduction to entropy;
- dealing with polluting exhaust emissions.

How Science Works

Aspects from the list in Appendix C studied in this module include:

ii. the design of simple experiments to measure the energy transferred;
vi. evaluation of these experiments;
ix. risks of pollutants from car petrol; benefits and risks of alternative fuels;
xii. informing society of the risks of pollutants from various fuels.

Links

The following is assumed knowledge from Key Stage 4:

- chemical change takes place by the rearrangement of atoms in substances;
- new materials are made from natural resources by chemical reactions;
- chemical synthesis (Additional Science).

The following topics in this teaching module are also treated in other teaching modules:

- bonding and shapes of covalent compounds (**EL** and many others);
- chemical formulae, amount of substance and equations (**EL** and many others); alcohols (**PR**, **WM**, **MR**, **MD**);
- entropy (**O**);
- nomenclature of organic compounds (**A**, **PR**, **WM**, **MR**, **CD**, **MD**);
- catalysis (**A**, **EP**, **SS**, **AA**).

Topic	Assessable learning outcomes
Formulae, equations and amount of substance **Energetics**	Candidates should be able to: (a) use the concept of amount of substance to perform calculations involving: volumes of gases, balanced chemical equations, enthalpy changes; (b) explain and use the terms: *exothermic*, *endothermic*, *standard state*, (*standard*) *enthalpy change of combustion* (ΔH_c), (*standard*) *enthalpy change of reaction* (ΔH_r), (*standard*) *enthalpy change of formation* (ΔH_f); (c) describe and design simple experiments to measure the energy transferred when reactions occur in solution or when flammable liquids burn; explain the limitations of such practical procedures and the uncertainties of measurement involved; (d) calculate enthalpy changes from experimental results, recalling the formula: heat transferred = mass × specific heat capacity × temperature change; describe the approximations in density and specific heat capacity of solutions made in these calculations; (e) use Hess' law to explain how enthalpy cycles can be used to calculate enthalpy changes of reaction, including *via* enthalpy changes of formation, combustion and bond enthalpies; carry out these calculations; (f) explain and use the term (*average*) *bond enthalpy* and relate bond enthalpy to the length and strength of a bond; recall that bond-breaking is an endothermic process and bond-making is exothermic and use these ideas to explain the overall enthalpy change for a reaction; (g) use the term *entropy* in a qualitative manner, interpreting it as a measure of the number of ways that molecules can be arranged; (h) describe the differences in magnitude of the entropy of a solid, a liquid, a solution and a gas;
Kinetics	(i) explain and use the terms: *catalyst* (a catalyst speeds up a chemical reaction but can be recovered chemically unchanged at the end of the reaction), *catalysis*, *catalyst poison*; *heterogeneous*; (j) describe a simple model to explain the function of a heterogeneous catalyst; (k) describe the use of catalysts (including zeolites) in isomerisation, reforming and cracking processes and in the control of exhaust emissions;
Inorganic chemistry and the Periodic Table	(l) describe and explain the origin of atmospheric pollutants including those from car exhausts and other sources: particulates, unburnt hydrocarbons, CO, CO_2, NO_x, SO_x; describe the environmental implications of these pollutants; discuss methods of reducing these pollutants and the decisions society has to make in using such methods;

Organic functional groups	(m) recall that crude oil consists of a mixture of compounds, mainly hydrocarbons (compounds of hydrogen and carbon only) that can be separated by fractional distillation; (n) recognise members of the following homologous series: alkanes, cycloalkanes, alkenes, arenes, alcohols, ethers; (o) explain and use the terms: *aliphatic*, *aromatic*, *saturated* and *unsaturated*; (p) use systematic nomenclature to name, and interpret the names of, alkanes and alcohols;
Organic reactions	(q) describe and write balanced equations for the combustion (oxidation) of alkanes and alcohols;
Isomerism	(r) draw and interpret structural formulae (full, shortened and skeletal); (s) use the concept of repulsion of areas of electron density to deduce the bond angles in organic molecules (including double bonds) (no treatment of small deviation of angle due to lone pair repulsion required); relate molecular shape to structural formulae and use wedges and dotted lines to represent 3D shape; (t) explain and use the term *isomerism* and recognise and draw structural isomers;
Applications	(u) explain what is meant by the octane number of a petrol in terms of the tendency of petrol towards auto-ignition which causes 'knocking' in a car engine, describing the effect of chain length and chain branching on the octane number; (v) describe what happens in isomerisation, reforming and cracking reactions of hydrocarbons; explain how these processes improve the performance of hydrocarbons as fuels; (w) understand the work of chemists in improving fuels and in searching for and developing fuels for the future including use of *oxygenates* and the hydrogen economy; (x) understand the benefits and risks associated with using fossil fuels and alternative fuels (biofuels, hydrogen, nuclear) and discuss the choices involved in making decisions about ensuring a sustainable energy supply.

3.2 AS Unit F332: *Chemistry of Natural Resources*

This unit covers the following teaching modules:

- (**ES**) Elements from the Sea;
- (**A**) The Atmosphere;
- (**PR**) Polymer Revolution.

Candidates are expected to apply knowledge, understanding and other skills gained in this unit to new situations and/or to solve related problems.

Recommended prior knowledge

Candidates should:

- have achieved Grade C or above in both GCSE Science and GCSE Additional Science, or GCSE Chemistry, or an equivalent standard in other appropriate Level 2 qualifications.

(**ES**) Elements from the Sea

A study of the extraction of halogens from minerals in the sea together with a study of the properties and uses of Group 7 elements and their compounds.

The chemical ideas in this teaching module are:

- halogen chemistry;
- redox chemistry;
- Periodic Table – electron configurations and periodicity of ionisation enthalpy;
- intermolecular dipole bonds;
- halogenoalkane chemistry;
- industrial chemistry.

How Science Works

Aspects from the list in Appendix C studied in this module include:

vi. resolving conflicting evidence for the rate of hydrolysis of the halogenoalkanes;
ix. risks of handling the halogens set against the benefits of uses of their compounds;
x. sustainability issues in the chemical industry.

Links

The following topics in this teaching module are also treated in other teaching modules:

- atomic structure (**EL**);
- amount of substance (**EL** and **DF** and most other teaching modules);
- bonding (**EL**, **PR**, **AI** and most other teaching modules);
- the Periodic Table (**EL**, **SS** and **AI**);
- redox (**SS**, **AI**);
- the chemical industry (**AI**);
- halogenoalkane chemistry (A).

Topic	Assessable learning outcomes
Formulae, equations and amount of substance	Candidates should be able to: (a) use the concept of amount of substance to perform calculations involving: molecular formulae, percentage yield, masses of reagents, volumes of gases and concentrations of solutions; write and interpret any balanced chemical equations required, including ionic equations; (b) recall and explain the procedure for carrying out an acid–alkali titration and be able to work out the results;
Atomic structure	(c) use conventions for representing the distribution of electrons in atomic orbitals (no treatment of the shapes of atomic orbitals is expected); (d) work out the electronic configuration of atoms from hydrogen to krypton, and the outer sub-shell structures of other main group elements, in terms of main energy levels and s-, p- and d-atomic orbitals and the elements' positions in the Periodic Table;
Bonding and structure	(e) draw and interpret simple electron '*dot-and-cross*' diagrams to show how atoms bond through ionic, covalent and dative covalent bonds and be able to describe a simple model of metallic bonding; use the electron pair repulsion principle to predict and explain the shapes of simple molecules (such as CH_4, NH_3, H_2O and SF_6) and ions (such as NH_4^+) with up to six outer pairs of electrons (any combination of bonding pairs and lone pairs) (no treatment of hybridisation or molecular orbitals is expected); recall the typical physical properties (melting point, solubility in water, ability to conduct electricity) characteristic of giant lattice (metallic, ionic, covalent network) and simple molecular structure types; (f) explain the term *electronegativity*; recall qualitatively the electronegativity trends in the Periodic Table; use relative electronegativity values to predict bond polarity in a covalent bond; decide whether a molecule is polar or non-polar from its shape and the polarity of its bonds; (g) explain, give examples of, and recognise in given examples the following types of intermolecular bonds: *instantaneous dipole–induced dipole bonds* (including dependence on branching and chain length of organic molecules), *permanent dipole–permanent dipole bonds*; (h) describe the structure of an ionic lattice and be able to draw the structure of compounds that have the sodium chloride lattice;

Redox	(i) calculate the oxidation state of specified atoms in formulae (including ions) and explain which species have been oxidised and which reduced in a redox reaction; use systematic nomenclature to name inorganic compounds; (j) describe redox reactions of s- and p-block elements and their compounds in terms of electron transfer, using half-equations to represent the oxidation and reduction reactions, and defining oxidation and reduction as loss and gain of electrons;
Inorganic chemistry and the Periodic Table	(k) recall that the Periodic Table lists elements in order of atomic (proton) number and groups elements together according to their common properties; recall the classification of elements into s-, p- and d-blocks: (i) recall and explain the relationship between the position of an element in the Periodic Table and the charge on its ion, (ii) recall the names and formulae of NO_3^-, SO_4^{2-}, CO_3^{2-}, OH^-, NH_4^+, HCO_3^-; write formulae for compounds formed between these ions and other given anions and cations; (l) recall the meaning of the term *ionisation enthalpy*, write equations for the successive ionisations of an element, and explain periodic and group trends in the properties of elements in terms of ionisation enthalpy; (m) recall the following physical properties of the halogens: appearance and physical state at room temperature, volatility, solubility in water and organic solvents; explain physical state and volatility of the halogens in terms of intermolecular bonds; (n) use given information to compare different methods of manufacturing chemicals industrially, in terms of atom economy, percentage yield, batch *versus* continuous process, siting the plant, cost of process and raw materials, waste disposal, safety; (o) explain and compare the relative reactivity of the halogens in terms of their oxidising ability; describe and write half-equations for the redox changes which take place: (i) when chlorine, bromine and iodine react with other halide ions, (ii) at the electrodes on electrolysis of aqueous halide solutions; (p) recall the reactions between halide ions (X^-) and silver ions (Ag^+) and write ionic equations to represent these precipitation reactions; (q) explain the risks associated with the storage and transport of the halogens (fluorine to iodine); (r) recall and describe some uses of halogen compounds which must be weighed against these risks, including: fluorine – making PTFE, HCFCs, in toothpaste, chlorine – making PVC, bleach, bromine – medicines, flame retardants,

	iodine – medicines, human nutrient;
Organic functional groups	(s) recognise and write formulae for examples of members of the following homologous series: halogenoalkanes and those met in unit F331; (t) use systematic nomenclature to name and interpret the names of halogenoalkanes and compounds for which naming was required in unit F331;
Organic reactions	(u) describe in outline the preparation of a chloroalkane from an alcohol using HCl; (v) describe and explain the principal stages in the purification of an organic liquid product: (i) shaking with sodium hydrogencarbonate solution to remove acidic impurities, (ii) separating from other immiscible liquids using a separating funnel, (iii) drying with anhydrous sodium sulfate, (iv) simple distillation to allow collection of the pure product; (w) describe and explain the characteristic properties of halogenoalkanes, comparing fluoro-, chloro-, bromo- and iodo- compounds; the following aspects are to be considered: (i) boiling points, (depend on intermolecular bonds), (ii) nucleophilic substitution with water and hydroxide ions to form alcohols, and with ammonia to form amines;
Reaction mechanisms	(x) explain and use the terms: *hydrolysis*, *substitution*, *nucleophile*; (y) use the S_N2 mechanism as a model to explain nucleophilic substitution in halogenoalkanes using 'curly arrows' (knowledge of the S_N1 mechanism or of the S_N1 or S_N2 nomenclature is not required); (z) explain how either bond enthalpy or bond polarity might affect the relative reactivities of the halogenoalkanes and explain how experimental evidence determines that the bond enthalpy is more important;
Isomerism	(aa) draw and interpret skeletal, structural and full structural formulae; use the concept of repulsion of areas of electron density to deduce the bond angles in organic molecules (including double bonds) (no treatment of small deviation of angle due to lone pair repulsion required); relate molecular shape to structural formulae and use wedges and dotted lines to represent 3D shape.

(**A**) The Atmosphere

A study of important chemical processes occurring in the atmosphere – the ozone layer and the greenhouse effect.

The chemical ideas in this module are:

- giant covalent structures;
- rates of reaction;
- chemical equilibrium;
- radical reactions;
- the electromagnetic spectrum and the interaction of radiation with matter.

How Science Works

Aspects from the list in Appendix C studied in this module include:

ix. the benefits and risks to us and the environment of CFCs and their replacements;
i. use of reaction mechanisms as models to explain chemical reactions;
vi. (and vii, xi) how the evidence for the ozone 'hole' was overlooked; the conflicting evidence for the relation between increased concentration of greenhouse gases and global warming;
x. the effect on the environment of CFCs and greenhouse gases;
xii. the ways in which society's decision making has been informed by science in the matters of the ozone hole and global warming.

Links

The following topics in this teaching module are also treated in other teaching modules:

- rates of reaction (**EP**);
- equilibrium (**EP**, **SS**, **O**);
- bond enthalpies (**DF**);
- radical reactions (**PR**);
- interaction of radiation with matter (**EL**, **WM**, **SS**, **CD** and **MD**).

Topic	Assessable learning outcomes
Bonding and structure	Candidates should be able to: (a) describe examples of giant covalent (network) structures, such as diamond and silicon(IV) oxide; explain differences in the physical properties of CO_2 and SiO_2 in terms of their different structures;
Kinetics	(b) recall (and explain in terms of collision theory) the way that concentration, pressure and surface area affect the rate of a reaction; (c) explain and use the terms: *enthalpy profile, activation enthalpy*; (d) use the concept of activation enthalpy to explain the qualitative effect of temperature changes on rate of reaction; (e) explain the role of catalysts in providing alternative routes of lower activation enthalpy; (f) explain homogeneous catalysis in terms of the formation of intermediates;
Equilibria	(g) explain and use the term: *dynamic equilibrium* (rates of forward and back reaction equal; constant concentrations of reactants and products; takes place in a closed system); (h) use le Chatelier's principle to describe and predict, in a homogeneous reaction, the qualitative effects on the position of equilibrium of changes in the following conditions: concentration, temperature, pressure;
Inorganic chemistry and the Periodic Table	(i) recall the gases present in the atmosphere: nitrogen, oxygen, argon, carbon dioxide – and their percentages, and the polluting gases and their sources from the **DF** module; (j) calculate, from given data, values for composition by volume measured in percentage concentration and in parts per million (ppm);
Organic reactions	(k) explain the chemical basis of the depletion of ozone in the stratosphere due to halogenoalkanes, in simple terms involving the formation of halogen atoms and the catalytic role of these atoms (and other radicals) in ozone destruction; explain the ease of photodissociation of the halogenoalkanes (fluoroalkanes to iodoalkanes) in terms of bond enthalpy; (l) discuss and evaluate the evidence that was gathered to support understanding of how ozone depletion in the stratosphere due to halogenoalkanes occurs and how the scientific community validated the results of this and other experiments (given information);

Reaction mechanisms	(m) describe the difference between homolytic and heterolytic bond fission and recognise examples; (n) recall the formation, nature and reactivity of radicals and explain the mechanism of a radical chain reaction involving initiation, propagation and termination; (o) use a radical mechanism as a model to explain the reaction of alkanes with halogens (a radical chain reaction in the presence of UV radiation to form halogenoalkanes);
Applications of organic chemistry	(p) explain why some properties of CFCs made them such useful compounds and discuss the relative advantages and disadvantages of replacement compounds for CFCs: hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs) and hydrocarbons;
Modern analytical techniques	(q) recall the way ozone is formed and destroyed in the stratosphere; recall the effects of ozone in the atmosphere, including: (i) ozone's action as a sunscreen in the stratosphere by absorbing high-energy UV (and the effects of such UV, including on human skin), (ii) polluting effects of ozone in the troposphere, causing problems including photochemical smog; (r) recall and discuss aspects of the research leading to the discovery of the 'hole' in the ozone layer and how the evidence was at first overlooked; (s) recall the following regions of the electromagnetic spectrum in order of increasing frequency: infrared, visible (red–blue), ultraviolet; recall, in terms of these, the principal radiations of the Earth and the Sun; (t) recall that: (i) molecules change in vibrational energy states (bonds vibrate more) when they absorb IR radiation, (ii) UV and visible radiation promote electrons to higher energy levels, sometimes causing bond breaking; vibrational and electronic energies of molecules are quantised; (u) calculate values for frequency and energy of electromagnetic radiation using the equation $\Delta E = h\nu$; (v) explain the 'greenhouse effect' in terms of: (i) solar energy reaches Earth mainly as visible and UVs, (ii) Earth absorbs some of this energy, heats up and radiates IR, (iii) greenhouse gases (eg carbon dioxide and methane) in the troposphere absorb some of this IR, in the 'IR window', (iv) absorption of IR by greenhouse gas molecules increases the vibrational energy of their bonds, the energy is transferred to other molecules by collisions, thus increasing their kinetic energy and raising the temperature, (v) greenhouse gas molecules also re-emit some of the

absorbed IR in all directions, some of which heats up the Earth,

(vi) increased concentrations of greenhouse gases lead to an enhanced greenhouse effect;

(w) discuss the evidence for the relationship between the increased concentration of gases and global warming;

(x) recall and discuss different approaches to the control of carbon dioxide emissions: burning fewer fossil fuels (alternative fuels and economy of use), increasing photosynthesis, burying or reacting carbon dioxide.

(**PR**) The Polymer Revolution

A study of the development of addition polymers.

The chemical ideas in this module are:

- hydrogen bonding;
- alkene reactions;
- addition polymerisation;
- *E*/*Z* isomerism (related to *cis-trans*);
- alcohol reactions;
- infrared spectra.

How Science Works

Aspects from the list in Appendix C studied in this module include:

ii. relate the solubility of a dissolving polymer to its molecular structure;
iii. predict the boiling points of liquids;
v. interpret infrared spectra.

Links

The following topics in this teaching module are also treated in other teaching modules:

- hydrogen bonding (most other teaching modules including **O**);
- polymerisation and the properties of polymers (**MR**);
- isomerism (**DF** and **EP**);
- reaction mechanisms (**ES**, **A**, **WM**, **CD** and **MD**);
- alcohols and carboxylic acids (**WM**, **MR** and **MD**).

Topic	Assessable learning outcomes
Bonding and structure	Candidates should be able to: (a) explain how hydrogen bonds form and describe and give examples of hydrogen bonding, including in water and ice; (b) explain the relative boiling points of substances in terms of intermolecular bonds; (c) describe and explain the solubility of a dissolving polymer based on poly(ethanol) (or other polymers, given information) in terms of its molecular structure: insoluble when very many or very few internal hydrogen bonds, soluble when an intermediate number of hydrogen bonds;
Organic functional groups	(d) recognise and write formulae for alkenes and use systematic nomenclature to name and interpret the names of alkenes; (e) recognise members of the following homologous series: aldehydes, ketones, carboxylic acids; (f) recall the difference between primary, secondary and tertiary alcohols from their structures and identify examples of them;
Organic reactions	(g) describe and explain the technique of heating under reflux for reactions involving volatile liquids; (h) explain and use the term *elimination reaction*; (i) explain and use the term *addition polymerisation* and predict the structural formula of the addition polymer formed from given monomer(s), and *vice versa*; (j) recall the addition reactions of alkenes with the following: bromine to give a dibromo compound (and the use of this as a test for unsaturation), hydrogen bromide to give a bromo compound, hydrogen in the presence of a catalyst to give an alkane (Ni with heat and pressure or Pt at room temperature and pressure), water in the presence of a catalyst to give an alcohol (conc. H_2SO_4, then add water or steam/H_3PO_4/ heat and pressure); (k) describe and explain the following properties of alcohols: (i) oxidation of alcohols to carbonyl compounds (aldehydes and ketones) and carboxylic acids with acidified dichromate(VI) solution, including the importance of the condition (reflux or distillation) under which it is done, (ii) dehydration of alcohols to form alkenes using heated Al_2O_3 or refluxing with conc. H_2SO_4;
Reaction mechanisms	(l) explain and use the terms: *addition, electrophile, carbocation*; use the mechanism of electrophilic addition as a model to explain the reaction between bromine and alkenes using ‘curly arrows’; explain how the products obtained when other anions are present confirm the model of the mechanism;

Isomerism	(m) recognise where *E*/*Z* isomerism occurs, explaining it in terms of lack of free rotation about C=C bonds when there are two different groups on each carbon; draw and interpret diagrams to represent *E/Z* isomers for alkenes which have the same groups on both sides of the double bond (*E* – opposite sides of bond; *Z* – same side of bond); in such molecules, describe '*E*' as '*trans*' and '*Z*' as '*cis*' and extend this *cis*-*trans* nomenclature to other, more complicated, alkenes (knowledge of Cahn–Ingold–Prelog priority rules will **not** be required);
Applications of organic chemistry	(n) understand how the uses of a polymer are related to its properties, explaining given examples and suggest uses for polymers based on their given properties; (o) explain and use the terms: *thermoplastic*, *thermoset* and *co-polymer*;
Modern analytical techniques	(p) use relevant given data to interpret (and make predictions of) infrared spectra for organic compounds containing a limited range of functional groups (hydroxyl, carbonyl and carboxylic acid groups); (q) understand that every compound has a distinctive 'fingerprint' in its infrared spectrum.

3.3 AS Unit F333: *Chemistry in Practice (Internal Assessment)*

This unit is teacher assessed and externally moderated by OCR.

Candidates are assessed in **five** skill areas. Teachers assess the ability of candidates to:

- **Skill I (Competence)** – carry out practical work competently and safely using a range of techniques;
- **Skill II (Measurement)** – carry out quantitative experiments accurately and make and record reliable and valid measurements with appropriate accuracy and precision;
- **Skill III (Analysis and Evaluation)** – apply chemical knowledge and processes to unfamiliar situations, to analyse and evaluate their own quantitative experiments;
- **Skill IV (Observation)** – make and record valid qualitative observations with appropriate accuracy and detail;
- **Skill V (Interpretation) –** recognise, recall and show understanding of chemical knowledge to interpret and explain their own qualitative experiments, with due regard to spelling, punctuation and grammar and correct use of technical terms.

Skill I is assessed over a period of time using a minimum of **six** different practical activities.

Skills II, III, IV and V may be assessed in separate activities or they may be assessed together in **two** separate activities as follows: Skills II and III; Skills IV and V. These activities and mark schemes are provided by OCR. Activity sheets from the course material should **not** be used for assessment.

See Appendix B for further details.

Authentication

Teachers must verify that, to the best of their knowledge, each task is the work of the candidate concerned.

3.4 A2 Unit F334: *Chemistry of Materials*

This unit covers the following teaching modules:

- (**WM**) What's in a Medicine?;
- (**MR**) The Materials Revolution;
- (**TL**) The Thread of Life;
- (**SS**) The Steel Story.

Candidates are expected to apply knowledge, understanding and other skills gained in this unit to new situations and/or to solve related problems.

Recommended prior knowledge

Candidates should:

- have achieved Grade C or above in both GCSE Science and GCSE Additional Science, or GCSE Chemistry, or an equivalent standard in other appropriate Level 2 qualifications.

(**WM**) What's in a Medicine?

A study of medicines such as aspirin, their development, chemistry and synthesis, illustrating some of the features of the pharmaceutical industry.

The chemical ideas in this module are:

- phenols, carboxylic acids, esters, carbonyl compounds;
- acid–base reactions;
- medicine manufacture and testing;
- IR spectroscopy and mass spectroscopy.

How Science Works

Aspects from the list in Appendix C studied in this module include:

ix. the benefits and risks of testing medicines;
x. the ethical issues involved in the testing of medicines;
xi. making new compounds and testing for medicinal effect;
xii. informing the public about medicine use and safety.

Links

The following topics in this teaching module are also treated in other teaching modules:

- acid–base reactions (**O**);
- organic groups (**MR**, **EP** and **MD**);
- medicine manufacture and testing (**MD**);
- mass spectroscopy (**EL** and **MD**);
- IR spectroscopy (**MD**).

Topic	Assessable learning outcomes
Equilibria	Candidates should be able to: (a) describe acids in terms of the Brønsted–Lowry theory as proton donors, and bases as proton acceptors, and identify the proton donor and proton acceptor in an acid–base reaction;
Bonding and structure	(b) draw and interpret simple electron '*dot-and-cross*' diagrams to show how atoms bond through ionic, covalent and dative covalent bonds and be able to describe a simple model of metallic bonding; use the electron pair repulsion principle to predict and explain the shapes of simple molecules (such as CH_4, NH_3, H_2O and SF_6) and ions (such as NH_4^+) with up to six outer pairs of electrons (any combination of bonding pairs and lone pairs) (no treatment of hybridisation or molecular orbitals is expected); recall the typical physical properties (melting point, solubility in water, ability to conduct electricity) characteristic of giant lattice (metallic, ionic, covalent network) and simple molecular structure types (synoptic);
Organic functional groups	(c) recognise and write formulae for members of the following homologous series: diols, diamines, dicarboxylic acids, phenols, acyl chlorides, acid anhydrides, esters and other homologous series met in the AS course (synoptic); (d) use systematic nomenclature to name and interpret the names of diols, carboxylic acids, dicarboxylic acids, esters, aldehydes and ketones, and other organic compounds whose naming was required in the AS course (synoptic);
Organic reactions	(e) recall the reactions (as described in the modules named) of halogenoalkanes (**ES**), alkenes (**PR**) and alcohols (**PR**) (synoptic); (f) describe and explain the acidic nature of carboxylic acids, and their reaction with alkalis and carbonates; (g) describe the reaction of alcohols with carboxylic acids in the presence of concentrated sulfuric acid or concentrated hydrochloric acid to form esters; (h) describe the following properties of phenols: acidic nature, and their reaction with alkalis but not carbonates; test with neutral iron(III) chloride solution, to give a purple colouration; reaction with acyl chlorides to form esters; (i) describe the following reactions involving carbonyl compounds (aldehydes and ketones): formation of carbonyl compounds by oxidation of alcohols using acidified dichromate with the need to distil in the case of aldehydes (synoptic); oxidation of aldehydes to carboxylic acids using acidified dichromate, under reflux; reaction with hydrogen cyanide to form the cyanohydrin; (j) describe the techniques for heating and purifying volatile liquids: heating under reflux and distillation (synoptic);
Reaction mechanisms	(k) describe the mechanism of the nucleophilic addition reaction between a carbonyl compound and hydrogen cyanide, using 'curly arrows' and bond polarities;

Applications of organic chemistry	(l) understand that more effective medicines can be obtained by modifying the structure of existing medicines; (m) discuss given examples and understand that combinatorial chemistry is used to make a large number of related compounds together, so that their potential effectiveness as medicines can be assessed by large-scale screening; (n) recall the meaning of the concept 'atom economy' (synoptic) and understand that most reactions used in chemical synthesis can be classified as: rearrangement, addition, substitution, elimination; understand that a condensation reaction is addition followed by elimination; classify a given reaction using these terms: (i) recall and understand that rearrangement and addition reactions have a higher atom economy than substitution and condensation reactions, which have a higher atom economy than elimination reactions, (ii) discuss the importance of 'atom economy' and reaction type in working towards the development of environmentally friendly industrial processes in the production of polymers and medicines; (o) understand that testing a medicine involves clinical trials which answer the following questions about a potential new drug: Step I – Is it safe? Step II – Does it work? Step III – Is it better than the standard treatment?;
Modern analytical techniques	(p) describe the technique of thin-layer chromatography (TLC), including location of spots using iodine or ultraviolet radiation, and interpret results in terms of number of spots and matching heights *or* R_f values with known compounds; understand that chromatography can be used for the purification of an organic substance; (q) interpret and predict mass spectra: identify the M^+ peak and explain that it indicates the M_r (synoptic); explain how the molecular formula can be worked out from the high-resolution value of the M^+ peak; recall that other peaks are due to positive ions from fragments and the mass differences between peaks; indicate the loss of groups of atoms, suggest the origins of peaks, eg peaks at masses of 15 and 77 are usually due to the presence of the methyl and phenyl positive ions; loss of a methyl group would be indicated by a mass difference of 15; (r) use information given in the *Data Sheet* to interpret and predict infrared spectra for organic compounds, in terms of the functional group(s) present; understand that specific frequencies of infrared radiation make specific bonds vibrate more.

(**MR**) The Materials Revolution

A study of condensation polymers and other modern materials.

The chemical ideas in this module are:

- condensation polymers;
- amines and amides;
- factors affecting the properties of polymers;
- disposal of polymers.

How Science Works

Aspects from the list in Appendix C studied in this module include:

ii, iii using scientific knowledge and methodology to modify the properties of polymers;

ix, xii consideration of the benefits and risks associated with the manufacture and disposal of polymers and the decisions facing society.

Links

The following topics in this teaching module are also treated in other teaching modules:

- polymers (**PR**);
- amines and amides (**EP**).

Topic	Assessable learning outcomes
Bonding and structure	Candidates should be able to: (a) explain the term *electronegativity*; recall qualitatively the electronegativity trends in the Periodic Table; use relative electronegativity values to predict bond polarity in a covalent bond; decide whether a molecule is polar or non-polar from its shape and the polarity of its bonds; explain, give examples of and recognise in given examples the following types of intermolecular bonds: instantaneous dipole–induced dipole bonds (including dependence on branching and chain length of organic molecules), permanent dipole–permanent dipole bonds, hydrogen bonds (synoptic); (b) explain and predict the effect of temperature, crystallinity and chain length on the properties of polymers: temperature – intermolecular bonds have more effect as the temperature is lowered; a polymer softens above its T_m and becomes brittle below its T_g; crystallinity (regular packing of the chains, due to the regular structure of the polymer) – the chains are closer and the intermolecular bonds have more effect, leading to greater strength; chain length – there are more intermolecular bonds leading to greater strength; explain that flexibility depends on the ability of the polymer chains to slide over each other; (c) explain the following ways that chemists can modify the properties of a polymer to meet particular needs: cold-drawing to make the structure more crystalline,

	copolymerisation, use of plasticisers; (d) understand that the properties of all materials depend on their structure and bonding and explain examples given relevant information;
Organic functional groups	(e) recognise members of the following homologous series: amines and amides; (f) use systematic nomenclature to name and interpret the names of aliphatic primary amines and diamines (use the prefix amino- for the NH_2 group together with the parent hydrocarbon, eg 2-aminopropane, 1,6-diaminohexane);
Organic reactions	(g) explain the difference between addition and condensation polymerisation; (h) predict the structural formula of the condensation polymer formed from given monomer(s), and *vice versa*; (i) describe the hydrolysis of esters and amides by both aqueous acids and alkalis, including salt formation where appropriate; (j) describe the following reactions of amines: neutralisation by acids, acylation to form an amide; (k) recall the procedure for purifying an organic solid product by recrystallisation, and explain that the solvent used: must be one in which the substance is very soluble at higher temperatures and insoluble, or nearly so, at lower temperatures; is saturated by the substance at higher temperatures, and on cooling the substance then crystallises out, to leave the impurities in solution;
Reaction mechanisms	(l) explain the basic nature of the amino group, in terms of a lone pair on the nitrogen accepting a proton to give a cation;
Applications	(m) understand how the principles of 'green chemistry' are important in the manufacture, use, recycling and the eventual disposal of polymers, including: (i) minimising any hazardous waste during production of raw materials and their resulting polymers to reduce any negative impact on the environment, (ii) reducing carbon emissions resulting from the 'life cycle' of a polymer, (iii) recycling to produce energy and chemical feedstocks.

(**TL**) The Thread of Life

A study of proteins and enzymes. DNA and its use in synthesising proteins.

The chemical ideas in this module are:

- rates of reaction;
- enzyme catalysis;
- optical isomerism;
- amino acid and protein chemistry;
- the structure and function of DNA.

How Science Works

Aspects from the list in Appendix C studied in this module include:

i, vii the proposal of several models for DNA before the current one;
x the use of enzymes in green chemistry;
x, xii the ethics of storing and using DNA data.

Links

The following topics in this teaching module are also treated in other teaching modules:

- rates of reaction (**DF**, **A**, **SS**);
- isomerism (**DF**, **PR**, **TL**, **MD**).

Topic	Assessable learning outcomes
Kinetics	(a) explain and use the terms: *rate of reaction*, *rate constant*, including units, *order of reaction* (both overall and with respect to a given reagent); use empirical rate equations of the form: rate = $k[A]^m[B]^n$ where m and n are integers; carry out calculations based on the rate equation; understand that the rate constant k increases with increasing temperature;
	(b) understand that these experimental methods can be used in a school laboratory for following a reaction: titration, pH measurement, colorimetry, measuring volumes of gases evolved, measuring mass changes;
	(c) design experiments using given information and explain how the results of such experiments can be used to calculate the rate of the reaction;
	(d) use given data to calculate half-lives for a reaction;
	(e) use experimental data (half-lives or initial rates when varying concentrations are used) to find the order of a reaction (zero-, first- or second-order), and hence construct a rate equation for the reaction;

	(f) use the term *rate-determining step* to describe the slowest step in a reaction; explain the shape of the rate *versus* substrate concentration curve for an enzyme-catalysed reaction in terms of the rate-determining step: at low concentrations of substrate the order with respect to the substrate is one, at higher concentrations of substrate the order with respect to the substrate is zero; explain, given the necessary data, the useful information about the mechanism of a reaction that can be obtained from the rate-determining step;
Organic functional groups	(g) recognise and describe the generalised structure of amino acids and recall that proteins are condensation polymers formed from amino acid monomers; (h) describe the primary, secondary and tertiary structure of proteins; explain the importance of amino acid sequence in determining the properties of proteins, and account for the diversity of proteins in living things; (i) explain the role of hydrogen bonds and other intermolecular bonds in determining the secondary and tertiary structures, and hence the properties of proteins;
Organic reactions	(j) describe the acid–base properties of amino acids and recall that they usually exist as zwitterions; (k) describe the formation and hydrolysis of the peptide link between amino acid residues in proteins and the use of paper chromatography to identify amino acids, including the need for a suitable locating agent, such as ninhydrin; (l) describe the characteristics of enzyme catalysis, including: specificity, temperature sensitivity, pH sensitivity, inhibition; (m) explain these characteristics of enzyme catalysis in terms of a three-dimensional active site (part of the tertiary structure) to which the substrate forms intermolecular bonds, recalling that molecules acting as inhibitors bind to active sites but do not react; (n) understand that DNA is a condensation polymer formed from nucleotides, which are monomers having three components: phosphate, sugar and base; explain, using the structures on the *Data Sheet*, how: phosphate units join by condensation with deoxyribose to form the phosphate–sugar backbone in DNA; the four bases present in DNA join by condensation with the deoxyribose in the phosphate sugar backbone; two strands of DNA form a double-helix structure through base pairing; understand that various models were devised before the currently accepted version was formulated; (o) using the structures on the *Data Sheet*, describe and explain the significance of hydrogen bonding in the pairing of bases in DNA, and relate to the replication of genetic information; use the diagram on the *Data Sheet* to explain how DNA encodes for an amino acid sequence in a protein;

Isomerism	(p)	draw and interpret structural formulae (full, shortened and skeletal); use the concept of repulsion of areas of electron density to deduce the bond angles in organic molecules (including double bonds, no treatment of small deviation of angle due to lone pair repulsion required); relate molecular shape to structural formulae and use wedges and dotted lines to represent 3D shape; recognise and draw structural isomers; recognise where *E*/*Z* isomerism occurs, explaining it in terms of lack of free rotation about C=C bonds when there are two different groups on each carbon; draw and interpret diagrams to represent *E*/*Z* isomers for alkenes which have the same groups on both sides of the double bond (*E* – opposite sides of bond; *Z* – same side of bond); in such molecules, describe '*E*' as '*trans*' and '*Z*' as '*cis*' and extend this *cis-trans* nomenclature to other, more complicated, alkenes (synoptic) (knowledge of Cahn–Ingold–Prelog priority rules will **not** be required);
	(q)	draw and interpret diagrams to represent optical stereo-isomers of molecules: explain and use the term *chiral* as applied to a molecule, and explain that *enantiomers* are non-superimposable mirror image molecules;
Applications	(r)	understand that DNA analysis can be used for 'genetic fingerprinting'; discuss the ethical issues of using and storing data from human DNA analysis, given examples;
	(s)	given examples, understand the industrial importance of enzymes and of their contribution to 'green chemistry' processes.

(**SS**) The Steel Story

An account of the production, properties and uses of steel, with reference to other metals.

The chemical ideas in this module are:

- redox reactions;
- electrode potentials;
- d-block chemistry;
- colorimetry.

How Science Works

Aspects from the list in Appendix C studied in this module include:

ii. devise procedures for acid–base and redox titrations;
v. solve unstructured titration problems;
xii. issues in the recycling of iron.

Links

The following topics in this teaching module are also treated in other teaching modules:

- redox (**ES**, **AI**);
- catalysis (**DF**, **A**, **EP**);
- colour (**A**, **CD**).

Topic	Assessable learning outcomes
Formulae, equations and amount of substance	Candidates should be able to: (a) use the concept of amount of substance to perform calculations involving: molecular formulae, masses of reagents, percentage yields, volumes of gases, volumes of solutions of known concentrations, balanced chemical equations (synoptic); (b) write and interpret balanced equations, including ionic, given the necessary information (synoptic); (c) given the necessary information, describe and explain procedures for acid–base (synoptic) and redox titrations and carry out non-structured calculations based on the results;
Atomic structure	See under inorganic chemistry and the Periodic Table
Bonding and structure	(d) use and explain the term *coordination number*: draw and name the shapes of complexes with coordination numbers 4 (square planar and tetrahedral) and 6 (octahedral);

Redox	(e) given the necessary information, describe redox reactions of d-block elements (and main group elements – synoptic) in terms of electron transfer: assigning oxidation states (synoptic), using half-equations to represent the oxidation and reduction reactions (synoptic), combining half-equations to give the overall equation for the reaction, recognising the oxidising and reducing agents, defining oxidation and reduction in terms of loss and gain of electrons; use systematic nomenclature to name and interpret the names of inorganic compounds [ie copper(II) sulfide, lead(II) nitrate(V), potassium manganate(VII), not complex ions]; (f) recall and explain the procedure for carrying out a redox titration involving manganate(VII) ions; (g) describe the construction of simple electrochemical cells involving: metal ion/metal half-cells, half-cells based on different oxidation states of the same element in aqueous solution with a platinum or other inert electrode, acidified if necessary; (h) explain and use the term *standard electrode potential* and understand how a standard electrode potential is measured using a hydrogen electrode (details of electrode not required); explain the action of an electrochemical cell in terms of half-equations and external electron flow; (i) use standard electrode potentials to: (i) calculate E_{cell}, (ii) predict the feasibility of redox reactions and understand that the rate of reaction may be an important factor in deciding whether the reaction actually takes place under standard conditions; (j) describe rusting in terms of electrochemical processes involving iron, oxygen and water, and the subsequent reactions to form rust; (k) describe and explain approaches to corrosion prevention: (i) sacrificial protection by galvanising and use of zinc blocks, (ii) barrier protection using oil, grease, paint or a polymer coating; (l) describe and explain the issues involved in the recycling of iron and steel: all steel packaging except aerosols can be recycled, cleaning by incineration, ease of sorting using magnetic properties, composition of new steel easily adjusted, scrap is used to adjust temperature of furnace;

Inorganic chemistry and the Periodic Table	(m) given the necessary information, explain the chemical processes occurring during the extraction and purification of metals from their ores;
	(n) recall that the Periodic Table lists elements in order of atomic (proton) number and groups elements together according to their common properties; recall the classification of elements into s-, p- and d-blocks;
	(i) recall and explain the relationship between the position of an element in the Periodic Table and the charge on its ion,
	(ii) recall the names and formulae of NO_3^-, SO_4^{2-}, CO_3^{2-}, OH^-, NH_4^+, HCO_3^-; write formulae for compounds formed between these ions and other given anions and cations (synoptic);
	(o) recall that transition metals are d-block elements forming one or more stable ions which have incompletely filled d orbitals; recall the common oxidation states of iron and copper and the colours of their aqueous ions;
	(p) describe the colour changes in and write ionic equations for the reactions of: Fe^{2+}(aq), Fe^{3+}(aq) and Cu^{2+}(aq) ions with sodium hydroxide solution, and Cu^{2+}(aq) ions with ammonia solution;
	(q) use conventions for representing the distribution of electrons in atomic orbitals (no treatment of the shapes of atomic orbitals is expected); write out the electronic configuration, using sub-shells and atomic orbitals, for atoms and ions of the first row of the d-block elements (and the main group elements up to krypton – synoptic) and use them to explain the existence of variable oxidation states, in terms of the stability of *d* orbital electron arrangements;
	(r) explain the catalytic activity of transition metals and their compounds: homogeneous catalysis in terms of variable oxidation states, heterogeneous catalysis in terms of the ability of transition metals to use (3)d and (4)s electrons of the atoms on the catalyst surface to form weak bonds to reactants;
	(s) explain and use the terms: *ligand*, *complex/complex ion*, *ligand substitution*, recalling the formulae of the following examples of complex ions from the chemistry of: iron: $[Fe(H_2O)_6]^{2+}$, $[Fe(H_2O)_6]^{3+}$; copper: $[Cu(H_2O)_6]^{2+}$, $[Cu(NH_3)_4]^{2+}$, $[CuCl_4]^{2-}$;
	(t) describe the formation of complexes in terms of coordinate (dative) bonding between ligand and central metal ion; explain the terms *bidentate* and *polydentate* as applied to ligands, exemplified by ethanedioate and $EDTA^{4-}$;
	(u) recall that the ions of transition metals in solution are often coloured and explain that this is because they absorb in specific parts of the visible spectrum and transmit the complementary frequencies (no explanation in terms of energy levels is required in this unit);
	(v) describe and explain a simple colorimeter, and use colorimetric measurements to determine the concentration of a coloured solution:

(i) choose suitable filter/set wavelength,
(ii) make up standard solutions of coloured solution,
(iii) zero colorimeter with tube of water/solvent,
(iv) measure absorbance of standard solutions,
(v) plot calibration curve,
(vi) measure absorbance of unknown,
(vii) read off concentration from calibration curve.

3.5 A2 Unit F335: *Chemistry by Design*

This unit covers the following teaching modules:

- (**AI**) Agriculture and Industry;
- (**CD**) Colour by Design;
- (**O**) The Oceans;
- (**MD**) Medicines by Design.

Candidates are expected to apply knowledge, understanding and other skills gained in this unit to new situations and/or to solve related problems.

Recommended prior knowledge

Candidates should:

- have achieved Grade C or above in both GCSE Science and GCSE Additional Science, or GCSE Chemistry, or an equivalent standard in other appropriate Level 2 qualifications.

(**AI**) Agriculture and Industry

A study of how chemists use industrial processes to benefit mankind and how they contribute towards a safe and efficient food supply.

The chemical ideas in this module are:

- an overview of structure and bonding, including shapes of molecules;
- equilibrium and equilibrium constant;
- an overview of the effects of factors on the rate and equilibrium yields of reactions, leading to a consideration of the best conditions for an industrial process;
- aspects of nitrogen chemistry, including the nitrogen cycle;
- an overview of redox reactions;
- a discussion of the costs of an industrial process, including hazards and their effect on society.

How Science Works

Aspects from the list in Appendix C studied in this module include:

ix the hazards of the chemical industry;

x, xii the effects of industrial processes on the environment; the ethics of using chemicals in agriculture.

Links

The following topics in this teaching module are also treated in other teaching modules:

- catalysis and rate of reaction (**DF**, **A**, **EP** and **SS**);
- chemical equilibrium (**A** and **O**);
- oxidation states (**ES** and **SS**);
- the Periodic Table and periodicity (**EL**, **ES** and **SS**);
- processes in the chemical industry (**ES**).

Topic	Assessable learning outcomes
Formulae and equations	Candidates should be able to: (a) use the concept of amount of substance to perform calculations involving: molecular formulae, masses of reagents, volumes of gases, concentrations of solutions, percentage composition, percentage yield and balanced chemical equations (synoptic); (b) write and interpret balanced chemical equations (including ionic equations) with state symbols (synoptic);
Atomic structure	(c) work out the electronic configuration of atoms and ions up to *Z* = 36 and the outer sub-shell structures of atoms and ions of other elements, in terms of main energy levels, s-, p- and d-atomic orbitals and the elements' positions in the Periodic Table (synoptic);
Bonding and structure	(d) suggest and explain the properties of substances in terms of their structure and bonding and position of their elements in the Periodic Table; draw and use simple electron '*dot-and-cross*' diagrams to show how atoms bond through ionic, covalent and dative covalent bonds and be able to describe a simple model of metallic bonding; recall the typical physical properties (melting point, solubility in water, ability to conduct electricity) characteristic of giant lattice (metallic, ionic, covalent network) and simple molecular structure types (synoptic); (e) describe the shapes of molecules and ions with up to six electron pairs (any combination of bonding and lone pairs), draw '*dot-and-cross*' diagrams, and explain these shapes in terms of electron repulsion theory (synoptic);
Rates of reaction	(f) describe and explain the effect of temperature, pressure and catalysts on the rate of a reaction (synoptic);
Equilibrium	(g) describe and explain the way in which changes of temperature and pressure and addition of catalysts affect the magnitude of the equilibrium constant and the position of equilibrium (latter synoptic); (h) use principles of equilibrium and rates of reaction to suggest and explain the most economical operating conditions for an industrial process; (i) write an expression for the equilibrium constant, K_c, for a given homogeneous reaction; (j) calculate one of the values in an equilibrium constant equation, given the others;
Redox	(k) calculate oxidation states and explain and write equations and half-equations for redox reactions (synoptic) including those involved in the interconversion of the following compounds in the nitrogen cycle: nitrogen gas, nitrate(V) ion, nitrate(III) ion, ammonium ion, oxides of nitrogen; define oxidation and reduction in terms of loss and gain of electrons; use systematic nomenclature to name and interpret the names of inorganic compounds [ie copper(II) sulfide, lead(II) nitrate(V), potassium manganate(VII), not complex ions];

Inorganic chemistry and the Periodic Table	(l) recall the following aspects of nitrogen chemistry: structure and bonding in nitrogen gas, ammonia and the ammonium ion, the appearance and names of the oxides of nitrogen, N_2O, NO, NO_2; (m) calculate from given data the percentage yield and the atom economy of an industrial process and suggest the effect of the process on the environment; (n) discuss given examples of industrial processes in terms of: costs of raw materials, energy costs, costs associated with plant, co-products and by-products, principles of green chemistry; (o) discuss the benefits and risks associated with given industrial processes in terms of: benefits to society of the product(s), hazards involved with the raw materials: reactants, products and by-products, explosions, acidic gases, flammable gases, toxic emissions; (p) discuss the facts and ethics associated with the ways in which chemists are involved in developments to improve food production, including: (i) providing extra nutrients, (ii) controlling soil pH, (iii) controlling pests.

A study of the chemical basis of colour in pigments, paints and the use of chemistry to provide colours to order.

The chemical ideas in this module are:

- the chemical origins of colour in transition metal compounds and organic compounds;
- aromatic compounds;
- analysing pigments and oils, restoring paintings;
- dyes and dyeing.

How Science Works

Aspects from the list in Appendix C studied in this module include:

i, ii, vii models of benzene structure;

viii describe the origins of colour in transition metal compounds or organic molecules.

Links

The following topics in this teaching module are also treated in other teaching modules:

- interaction of radiation with matter (**EL**, **A**, **WM**, **SS** and **MD**);
- spectroscopy (**EL**, **WM** and **MD**);
- organic functional groups (**DF**, **A**, **WM**, **MR**, **EP** and **MD**);
- intermolecular attractions and their influence on properties (**ES**, **PR**, **MR**, **EP** and **O**);
- aromatic compounds (**DF**, **WM**, **MR** and **MD**).

Topic	Assessable learning outcomes
Bonding and structure	Candidates should be able to : (a) explain the term *electronegativity*: recall qualitatively the electronegativity trends in the Periodic Table; use relative electronegativity values to predict bond polarity in a covalent bond; decide whether a molecule is polar or non-polar from its shape and the polarity of its bonds; explain, give examples of and recognise in given examples the following types of intermolecular bonds: *instantaneous dipole–induced dipole bonds* (including dependence on branching and chain length of organic molecules), *permanent dipole–permanent dipole bonds, hydrogen bonds* (synoptic); (b) suggest and explain in terms of intermolecular bonds, ionic attractions and covalent bonding, how some dyes attach themselves to fibres; (c) describe and explain the structure of a dye molecule in terms of the chromophore and: (i) functional groups that modify the chromophore, (ii) functional groups that affect the solubility of the dye, (iii) functional groups that allow the dye to bond to fibres;

Organic functional groups	(d) recall that fats and oils consist mainly of mixed esters of propane-1,2,3-triol with varying degrees of unsaturation; (e) (i) recognise arenes and their derivatives (aromatic compounds), (ii) describe the delocalisation of electrons in these compounds, (iii) explain how delocalisation accounts for their characteristic properties [*limited to undergoing substitution (often slowly) rather than addition reactions*]; (f) understand that our knowledge of science progresses by the development of increasingly refined models to explain concepts and observations and that the nature of scientific knowledge is often tentative; understand that various models have been proposed to explain the bonding in aromatic compounds and discuss how various representations of benzene account for its properties and molecular shape;
Organic reactions	(g) describe and explain the following electrophilic substitution reactions of arenes, naming the benzene derivatives formed: (i) halogenation of the ring, (ii) nitration, (iii) sulfonation, (iv) Friedel–Crafts alkylation and acylation (including use of ionic liquids); (h) describe and explain the formation of diazonium compounds and coupling reactions that these undergo to form azo dyes;
Modern analytical techniques	(i) explain the origins of colour in transition metal complexes in terms of the splitting of the d orbitals by the ligands and transitions between the resulting electronic energy levels (details of how the d electrons split in a particular complex are not required); (j) explain the origins of colour (and UV absorption) in organic molecules in terms of: (i) transitions between electronic energy levels, (ii) the relationship between the extent of delocalisation in the chromophore and the energy absorbed; (k) describe and explain the general principles of gas–liquid chromatography: (i) sample injected into inert carrier gas stream, (ii) column consisting of high boiling liquid on porous support, (iii) detection of the emerging compounds (sometimes involving mass spectroscopy), (iv) distinguishing compounds by their retention times; (l) understand the techniques used to identify the materials used in a painting, including: (i) gas–liquid chromatography,

(ii) atomic emission spectroscopy,

(iii) visible spectroscopy (reflection and absorption),

and explain and predict given results from these techniques.

(**O**) The Oceans

A study of the role of the oceans in cycling chemicals, including salts and carbon dioxide, and maintaining pH, ie the importance of the oceans to life on Earth.

The chemical ideas in this module are:

- dissolving;
- acid–base equilibria and pH;
- entropy;
- disposing of carbon dioxide.

How Science Works

Aspects from the list in Appendix C studied in this module include:

vi. simplifications in calculating pH;

ix. implications of methods of disposing of carbon dioxide.

Links

The following topics in this teaching module are also treated in other teaching modules:

- entropy (**DF**);
- acid–base (**WM**);
- chemical equilibrium (**A** and **AI**);
- interaction of carbon dioxide with water (**A**).

Topic	Assessable learning outcomes
Bonding and structure	Candidates should be able to: (a) explain the hydrogen bonding in water and explain the unusual physical properties of water that arise from this: (i) anomalous boiling point among hydrides of Group 6, (ii) specific heating capacity, (iii) enthalpy change of vaporisation, (iv) density change on melting; (b) explain the factors (including intermolecular bonds and ion–dipole forces) determining the relative solubility of a solute in aqueous and non-aqueous solvents and explain the hydration of ions;
Energetics	(c) For the following terms: *enthalpy change of solution*, *lattice enthalpy*, *enthalpy change of solvation (hydration) of ions*: (i) explain and use these terms, (ii) describe the solution of an ionic solid in terms of an enthalpy cycle involving these terms, (iii) use these enthalpy cycles to perform calculations; (d) explain entropy changes in a qualitative manner, interpreting entropy as a measure of the number of ways that molecules and their associated energy quanta can be arranged (part synoptic); (e) (i) recall the expressions: $\Delta S_{tot} = \Delta S_{sys} + \Delta S_{surr}$, $\Delta S_{surr} = -\Delta H/T$, (ii) be able to perform calculations using these expressions, (iii) explain the tendency for a reaction to occur in terms of the sign of ΔS_{tot}; (f) calculate the entropy change of a reaction given the entropies of reactants and products;
Inorganic chemistry and the Periodic Table	(g) recall the meaning of the term *ionisation enthalpy*, write equations for the successive ionisations of an element, and interpret periodic and group trends in the properties of elements in terms of ionisation enthalpy (synoptic); (h) recall and explain the relationship between the position of an element in the Periodic Table and the charge on its ion; (i) recall the names and formulae of NO_3^-, SO_4^{2-}, CO_3^{2-}, OH^-, NH_4^+, HCO_3^-; write formulae for compounds formed between these ions and other given anions and cations (synoptic);
Equilibria	(j) describe acids in terms of the Brønsted–Lowry theory as proton donors and bases as proton acceptors (synoptic) and explain and use the terms *conjugate acid* and *conjugate base*; (k) explain and use the terms *strong acid, strong base*, writing equations for their ionisation in water; (l) explain and use the terms *weak acid* (writing equations for their ionisation in water), *acidity constant* ('dissociation constant') K_a, pK_a;

(m) explain and use the term *pH* and use given data to calculate the pH of:

(i) strong acids,

(ii) strong bases, using K_w (value will be given),

(iii) weak acids (including calculating any of the terms pH, K_a and concentration from any two others, being aware of the approximations made in using a simple equation);

(n) for *buffer solutions* based on solutions of weak acids and their salts:

(i) explain the meaning of the term *buffer*,

(ii) explain how buffers work (including in everyday applications),

(iii) carry out buffer solution calculations;

(o) discuss the global influence of the dissolving of carbon dioxide in water, discuss and explain the benefits and risks associated with various approaches to reducing atmospheric CO_2 levels including: more economical use of fuels, the use of alternative fuels (including hydrogen), capture and storage of CO_2 and increased photosynthesis.

An account of the way chemical principles and techniques are used to investigate the effect of chemicals on the body, and to design and make pharmaceutical substances to meet specific needs.

The chemical ideas in this module are:

- molecular recognition;
- computer modelling and design of drugs;
- synthesis of organic molecules;
- NMR spectroscopy;
- using spectroscopic techniques to elucidate structure.

How Science Works

Aspects from the list in Appendix C studied in this module include:

v analyse data from IR, NMR and mass spectra;

x, xi drug testing.

Links

The following topics in this teaching module are also treated in other teaching modules:

- reactions of organic functional groups (**DF**, **ES**, **A**, **WM**, **PR**, **MR**, **EP** and **CD**);
- proteins and enzymes (**EP**);
- interpretation of spectroscopic data (**PR** and **WM**);
- pharmaceutical chemistry (**WM**).

Topic	Assessable learning outcomes
Bonding and structure	(a) describe and explain the structure and action of a given pharmacologically active material in terms of: (i) the pharmacophore and groups that modify it, (ii) its interaction with receptor sites, (iii) the ways that species interact in three dimensions (size, shape, bond formation, orientation);
Organic functional groups	(b) recall and use systematic nomenclature for naming and interpreting names of compounds met earlier in the specification (AS and A2) (synoptic); (c) recognise and draw structures for individual functional groups mentioned elsewhere in the specification (AS and A2) within a polyfunctional molecule (synoptic); hence make predictions about its properties;
Organic reactions	(d) recall organic reactions and reaction conditions mentioned elsewhere in the specification (AS and A2) (synoptic); use these with any further given reactions, to suggest and explain synthetic routes for preparing organic compounds including simple examples of retrosynthesis; (e) use the following terms to classify organic reactions: *addition*, *condensation*, *elimination*, *substitution*, *oxidation*, *reduction*, *hydrolysis* (synoptic);

Reaction mechanisms	(f)	use and explain the following terms: *radical*, *electrophile*, *nucleophile*, *carbocation*, *saturated*, *unsaturated* (synoptic);
	(g)	use the following terms to classify organic reactions according to their reaction mechanisms: (i) *radical substitution**, (ii) *electrophilic addition**, (iii) *nucleophilic substitution**, (iv) *electrophilic substitution*, (v) *nucleophilic addition**, *be able to describe and explain the mechanisms of these processes in terms of bond polarisations and 'curly arrows' (synoptic);
Isomerism	(h)	draw and interpret skeletal, structural and full structural formulae as representations of molecules; use the concept of repulsion of areas of electron density to deduce the bond angles in organic molecules (including double bonds) (no treatment of small deviation of angle due to lone pair repulsion required); relate molecular shape to structural formulae and use wedges and dotted lines to represent 3D shape; recognise where *E*/*Z* isomerism occurs, explaining it in terms of lack of free rotation about C=C bonds when there are two different groups on each carbon; draw and interpret diagrams to represent *E*/*Z* isomers for alkenes which have the same groups on both sides of the double bond (*E* – opposite sides of bond; *Z* – same side of bond); in such molecules, describe '*E*' as '*trans*' and '*Z*' as '*cis*' and extend this *cis-trans* nomenclature to other, more complicated, alkenes (knowledge of Cahn–Ingold–Prelog priority rules will **not** be required); explain and use the term *chiral* as applied to a molecule; explain that *enantiomers* are non-superimposable mirror image molecules (synoptic);
Applications	(i)	describe and explain the role of chemists in: (i) designing and making new compounds for use as pharmaceuticals, (ii) ethical testing, (iii) the application of computer modelling techniques in the design of medicines;
Modern analytical techniques	(j)	describe and explain how proton nuclear magnetic resonance spectra (NMR) can be used for the elucidation of molecular structure (*including splitting patterns up to quartets – using the 'n + 1' rule; further explanation of splitting not required*);
	(k)	explain how a combination of spectroscopic techniques [MS, IR (synoptic) and NMR] can be used to elucidate the structure of organic molecules.

3.6 A2 Unit F336: *Chemistry Individual Investigation (Internal Assessment)*

This unit is teacher assessed and externally moderated by OCR.

Candidates carry out a single individual investigation. The topic may be taken from any aspect of chemistry. Candidates are expected to spend **about 18 hours** in the laboratory carrying out practical work as part of their investigation, and an **appropriate amount of time both before and after** this period preparing for and using the results of their investigation.

Candidates are assessed in **eight** skill areas (A–H). Teachers assess the ability of candidates to:

Skill Area A (Chemical ideas) – apply scientific knowledge and processes to unfamiliar situations (6 marks);

Skill Area B (Methods) – select and describe appropriate qualitative and quantitative methods (6 marks);

Skill Area C (Communication) – select, organise and communicate relevant information with due regard to spelling, punctuation and grammar and the accurate use of specialist vocabulary (5 marks);

Skill Area D (Observations and measurements) – make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy (6 marks);

Skill Area E (Analysis and interpretation) – analyse and interpret the results of investigative activities (6 marks);

Skill Area F (Evaluation) – explain and evaluate the methodology and results of investigative activities (6 marks);

Skill Area G (Manipulation) – demonstrate safe and skilful practical techniques and processes (5 marks);

Skill Area H (Demand) – develop and apply familiar and new chemical knowledge and processes in demanding situations (5 marks).

Quality of Written Communication is also assessed in this unit.

The marks for the eight skill areas are added together to provide a mark out of 45 for this unit which is submitted to OCR.

See Appendix B for further details.

Authentication

Candidates must complete and hand in their investigation report in **three separate sections**. Teachers must verify that, to the best of their knowledge, **each section is the work of the candidate concerned.**

4 Schemes of Assessment

4.1 AS GCE Scheme of Assessment

There are four written question papers in the Scheme of Assessment. Two of these are AS papers (Units F331 and F332); two are A2 papers (Units F334 and F335).

Questions on the examination papers in Units F331, F332, F334 and F335 reflect the nature of the course and are set in context. The contexts may be familiar ones from the course materials or they may be unfamiliar to candidates, requiring them to apply knowledge and understanding in new situations. In all four examination papers, a substantial proportion of the questions are presented in the context of the applications of chemistry and the work of chemists.

The questions on these papers are concerned principally with the teaching module specified. (The detailed content of these is provided in **Section 3**.) However, it is assumed that candidates have knowledge and understanding related to earlier modules, in keeping with the 'drip-feed' development of concepts in the course. Thus, questions may be set on a chemical concept used or developed in the specified teaching module, even though that concept may have been first introduced in an earlier unit. Questions will **not** be set on chemical ideas covered in earlier units, when these chemical ideas are not revisited in the specified module. As far as possible this has been indicated by the inclusion of the relevant learning outcomes relating to earlier units in the specification for each unit.

The first three written units have approximately 10% of the marks for extended writing and the final unit approximately 20%. All four papers include questions relating to the quantitative aspects of chemistry.

AS GCE Chemistry B (Salters) (H035)	
AS Unit F331: *Chemistry for Life*	
30% of the total AS GCE marks 1.25 h written paper 60 marks	Candidates answer **all** questions.
AS Unit F332: *Chemistry of Natural Resources*	
50% of the total AS GCE marks 1.75 h written paper 100 marks	Candidates answer **all** questions. One question will be on an **Advance Notice** article which will be available to centres *via* OCR Interchange and will be included as an insert with the question paper. For further details on the **Advance Notice** article see Appendix G.
AS Unit F333: *Chemistry in Practice*	
20% of the total AS GCE marks Coursework 60 marks	Five skills are assessed by the teacher. One skill requires the wide-ranging assessment of ability to work competently over a range of different practical areas. The other skills are focused on practical activities set by OCR, completed by the candidates under controlled conditions and marked by teachers (and moderated by OCR) against mark schemes set by OCR. **Assessment Criteria**: Please refer to Appendix B.

4.2 Advanced GCE Scheme of Assessment

Advanced GCE Chemistry B (Salters) (H435)	
AS Units as above, Unit F331 being 15% of the total Advanced GCE marks Unit F332 being 25% of the GCE marks Unit F333 being 10% of the total Advanced GCE marks	
A2 Unit F334: *Chemistry of Materials*	
15% of the total Advanced GCE marks 1.5 h written paper 90 marks	Candidates answer **all** questions. This unit is synoptic.
A2 Unit F335: *Chemistry by Design*	
20% of the total Advanced GCE marks 2 h written paper 120 marks	Candidates answer **all** questions. This unit is synoptic.
A2 Unit F336: *Chemistry Individual Investigation*	
15% of the total Advanced GCE marks Coursework 45 marks	Candidates work on a chemical investigation of their choice. The reports will be marked and authenticated by the teacher and moderated by OCR. Please also refer to Appendix B.

4.3 Unit Order

The normal order in which the unit assessments could be taken is AS Units F331, F332 and F333 in the first year of study, leading to an AS GCE award, then A2 Units F334, F335 and F336 leading to the Advanced GCE award.

Alternatively, candidates may take a valid combination of unit assessments at the end of their AS GCE or Advanced GCE course in a 'linear' fashion.

4.4 Unit Options (at AS/A2)

There are no optional units in the AS GCE specification; for AS GCE Chemistry B (Salters) candidates must take AS Units F331, F332 and F333.

There are no optional units in the Advanced GCE specification; for Advanced GCE Chemistry B (Salters) candidates take AS Units F331, F332 and F333, *and* A2 Units F334, F335 and F336.

4.5 Synoptic Assessment (A Level GCE)

Synoptic assessment tests the candidates' understanding of the connections between different elements of the subject.

Synoptic assessment involves the explicit drawing together of knowledge, understanding and skills learned in different parts of the Advanced GCE course. The emphasis of synoptic assessment is to encourage the development of the understanding of the subject as a discipline. All A2 units, whether internally or externally assessed contain synoptic assessment.

Synoptic assessment requires candidates to make and use connections within and between different areas of chemistry 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;
- bringing together scientific knowledge and understanding from different areas of the subject and applying them.

4.6 Assessment Availability

There is one examination series each year in June.

From 2014, both AS units and A2 units will be assessed in June only.

4.7 Assessment Objectives

Candidates are expected to demonstrate the following in the context of the content described:

AO1 Knowledge and Understanding

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

AO2 Application of Knowledge and Understanding

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

AO3 How Science Works

- 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;
- analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.

AO Weightings in AS GCE

Unit	% of AS GCE			Total
	AO1	AO2	AO3	
AS Unit F331: *Chemistry for Life*	16	11	3	30%
AS Unit F332: *Chemistry of Natural Resources*	20	23	7	50%
AS Unit F333: *Chemistry in Practice*	2	2	16	20%
	38%	36%	26%	100%

AO Weightings in Advanced GCE

Unit	% of Advanced GCE			Total
	AO1	AO2	AO3	
AS Unit F331: *Chemistry for Life*	8	5.5	1.5	15%
AS Unit F332: *Chemistry of Natural Resources*	10	11.5	3.5	25%
AS Unit F333: *Chemistry in Practice*	1	1	8	10%
A2 Unit F334: *Chemistry of Materials*	5	6	4	15%
A2 Unit F335: *Chemistry by Design*	5	13	2	20%
A2 Unit F336: *Chemistry Individual Investigation*	2	2.5	10.5	15%
	31%	39%	30%	100%

4.8 Quality of Written Communication

Quality of Written Communication is assessed in all units and credit may be restricted if communication is unclear.

Candidates will:

- 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 purpose and to complex subject matter;
- organise information clearly and coherently, using specialist vocabulary when appropriate.

5 Technical Information

5.1 Making Unit Entries

Please note that centres must be registered with OCR in order to make any entries, including estimated entries. It is recommended that centres apply to OCR to become a registered centre well in advance of making their first entries. Centres must have made an entry for a unit in order for OCR to supply the appropriate forms or moderator details for internally assessed work.

It is essential that unit entry codes are quoted in all correspondence with OCR. See Sections 4.1 and 4.2 for these unit entry codes.

5.2 Making Qualification Entries

Candidates must enter for qualification certification separately from unit assessment(s). If a certification entry is **not** made, no overall grade can be awarded.

Candidates may enter for:

- AS GCE certification (entry code H035);
- Advanced GCE certification (entry code H435).

A candidate who has completed all the units required for the qualification, and who did not request certification at the time of entry, may enter for certification either in the same examination series (within a specified period after publication of results) or in a later series.

AS GCE certification is available from June 2014.
Advanced GCE certification is available from June 2014.

5.3 Grading

All GCE units are awarded a–e. The Advanced Subsidiary GCE is awarded on the scale A–E with access to an A*. 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. Grades are reported on certificates. Results for candidates who fail to achieve the minimum grade (E or e) will be recorded as unclassified (U or u) and this is **not** certificated.

A Uniform Mark Scale (UMS) enables comparison of candidates' performance across units and across series and enables candidates' scores to be put on a common scale for aggregation purposes. The three-unit AS GCE has a total of 300 *uniform* marks and the six-unit Advanced GCE has a total of 600 *uniform* marks.

OCR converts the candidate's raw mark for each unit to a *uniform* mark. The maximum *uniform* mark for any unit depends on that unit's weighting in the specification. In these Chemistry B (Salters) specifications the six units of the Advanced GCE specification have *uniform* mark weightings of 15%/25%/10%/15%/20%/15% (and the three units of the AS GCE specification have *uniform* mark weightings of 30%/50%/20%). The *uniform* mark totals are 90/150/60/90/120/90, respectively. Each unit's *raw* mark grade boundary equates to the *uniform* mark boundary at the same grade. Intermediate marks are converted on a *pro-rata* basis.

Uniform marks correspond to *unit* grades as follows:

(Advanced GCE) Unit Weighting	Maximum Unit Uniform Mark	Unit Grade					
		a	b	c	d	e	u
25%	150	150–120	119–105	104–90	89–75	74–60	59–0
20%	120	120–96	95–84	83–72	71–60	59–48	47–0
15%	90	90–72	71–63	62–54	53–45	44–36	35–0
10%	60	60–48	47–42	41–36	35–30	29–24	23–0

OCR adds together the unit *uniform* marks and compares these to pre-set boundaries (see the table below) to arrive at *qualification* grades.

Qualification	Qualification Grade					
	A	B	C	D	E	U
AS GCE	300–240	239–210	209–180	179–150	149–120	119–0
Advanced GCE	600–480	479–420	419–360	359–300	299–240	239–0

Candidates achieving at least 480 *uniform* marks in their Advanced GCE, ie grade A, and who also gain at least 270 *uniform* marks in their three A2 units will receive an A* grade.

5.4 Result Enquiries and Appeals

Under certain circumstances, a centre may wish to query the grade available to one or more candidates or to submit an appeal against the outcome of such an enquiry. Enquiries about unit results must be made immediately following the series in which the relevant unit was taken.

For procedures relating to enquires on results and appeals, centres should consult the OCR *Administration Guide for General Qualifications* and the document *Enquiries about Results and Appeals – Information and Guidance for Centres* produced by the Joint Council. Copies of the most recent editions of these papers can be obtained from OCR.

5.5 Shelf-life of Units

Individual unit results, prior to certification of the qualification, have a shelf-life limited only by that of the qualification.

5.6 Unit and Qualification Re-sits

There is no restriction on the number of times a candidate may re-sit each unit before entering for certification for an AS GCE or Advanced GCE.

Candidates may enter for the full qualifications an unlimited number of times.

5.7 Guided Learning Hours

AS GCE Chemistry B (Salters) requires **180** guided learning hours in total.
Advanced GCE Chemistry B (Salters) requires **360** guided learning hours in total.

5.8 Code of Practice/Subject Criteria/Common Criteria Requirements

These specifications comply in all respects with current *GCSE, GCE, GNVQ and AEA Code of Practice* as available on the QCA website, the subject criteria for GCE Chemistry and *The Statutory Regulation of External Qualifications 2004*.

5.9 Arrangements for Candidates with Particular Requirements

For candidates who are unable to complete the full assessment or whose performance may be adversely affected through no fault of their own, teachers should consult the *Access Arrangements and Special Consideration Regulations and Guidance Relating to Candidates who are Eligible for Adjustments in Examinations* produced by the Joint Council. In such cases advice should be sought from OCR as early as possible during the course.

5.10 Prohibited Qualifications and Classification Code

Candidates who enter for the OCR GCE specifications may not also enter for any other GCE specification with the certification title *Chemistry* in the same examination series.

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

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

The classification code for these specifications is 1110.

5.11 Coursework Administration/Regulations

Supervision and Authentication

As with all coursework, teachers must be able to verify that the work submitted for assessment is the candidate's own work. Sufficient work must be carried out under direct supervision to allow the teacher to authenticate the coursework marks with confidence.

Submitting Marks to OCR

Centres must have made an entry for a unit in order for OCR to supply the appropriate forms or moderator details for coursework. Coursework administration documents are sent to centres on the basis of estimated entries. Marks may be submitted to OCR either *via* Interchange, on the computer-printed Coursework Mark Sheets (MS1) provided by OCR (sending the top copy to OCR and the second copy to their allocated moderator) or by EDI (centres using EDI are asked to print a copy of their file and sign it before sending to their allocated moderator).

Deadline for the receipt of coursework marks is:
15 May for the June series.

The awarding body requires centres to obtain from each candidate a signed declaration that authenticates the work they produce as their own. For regulations governing internally assessed work, centres should consult the OCR *Administration Guide for General Qualifications.* Further copies of the coursework administration documents are available on the OCR website (www.ocr.org.uk).

Standardisation and Moderation

All internally-assessed coursework is marked by the teacher and internally standardised by the centre. Marks must be submitted to OCR by the agreed date, after which postal moderation takes place in accordance with OCR procedures.

The purpose of moderation is to ensure that the standard for the award of marks in internally-assessed coursework is the same for each centre, and that each teacher has applied the standards appropriately across the range of candidates within the centre.

The sample of work which is submitted to the moderator for moderation must show how the marks have been awarded in relation to the marking criteria.

Minimum Coursework Required

If a candidate submits no work for a unit, then the candidate should be indicated as being absent from that unit on the mark sheets submitted to OCR. If a candidate completes any work at all for that unit then the work should be assessed according to the criteria and marking instructions and the appropriate mark awarded, which may be zero.

6 Other Specification Issues

6.1 Overlap with other Qualifications

Links with other AS and advanced GCE specifications.

Chemistry sits centrally within the sciences and this course provides overlap with other A-Level science specifications. The specification in science emphasises links between chemistry and related subjects such as biology, geology, physics and science.

Examples of overlap include:

Biology

- Unit F332: *Chemistry of Natural Resources*. Climate change.
- Unit F334: *Chemistry of Materials*. Amino acids, proteins, DNA, enzyme catalysis chromatography.

Geology

- Unit F332: *Chemistry of Natural Resources*. Climate change, the atmosphere.

Physics

- Unit F331: *Chemistry for Life.* Atomic structure.

Science

- Unit F331: *Chemistry for Life*. Atomic structure, enthalpy changes.
- Unit F332: *Chemistry of Natural Resources*. Climate change, the atmosphere, the development of renewable alternatives to finite energy resources, rates of reaction, catalysis.
- Unit F334: *Chemistry of Materials*. Amino acids, DNA, proteins, infrared spectroscopy, chromatography.

6.2 Progression from these Qualifications

Throughout the course, candidates are introduced to the ideas of chemistry and their application to a variety of contexts, both every day and more specialised. Their understanding of How Science Works in chemistry is deepened.

The specification thus provides a valuable education for candidates who take chemistry or related subjects no further. It is also an excellent foundation for further study of chemistry, medicine (and related subjects such as pharmacy and pharmacology) or other sciences.

6.3 Key Skills Mapping

These specifications provide opportunities for the development of the Key Skills of *Communication*, *Application of Number*, *Information Technology*, *Working with Others*, I*mproving Own Learning and Performance* and *Problem Solving* at Levels 2 and/or 3. However, the extent to which this evidence fulfils the Key Skills criteria at these levels will be totally dependent on the style of teaching and learning adopted for each unit.

The following table indicates where opportunities *may* exist for at least some coverage of the various Key Skills criteria at Levels 2 and/or 3 for each unit.

Unit	C				AoN			IT			WwO			IoLP			PS		
	.1a	.1b	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3
F331	✓	✓						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
F332	✓	✓						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
F333				✓	✓	✓	✓	✓	✓	✓									
F334	✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
F335	✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
F336		✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓

6.4 Spiritual, Moral, Ethical, Social, Legislative, Economic and Cultural Issues

Moral, ethical and some legislative issues are considered and discussed in the consideration of ‘How Science Works’ related to chemistry.
Economic issues are covered in relation to the chemical industry (mainly modules **ES** and **AI**).
Cultural issues are particularly dealt with in the relationship between chemistry and art (module **CD**).

6.5 Sustainable Development, Health and Safety Considerations and European Developments

- Sustainable development is considered frequently, particularly when considering energy sources and the recycling of materials.
- Health and safety is paramount in a potentially dangerous subject like chemistry and it is a thread running through the entire course, particularly stressed in the two internally assessed units (F333 and F336).
- Chemistry is always presented using international examples of research and best practice.

6.6 Avoidance of Bias

OCR has taken great care in the preparation of these specifications and assessment materials to avoid bias of any kind.

6.7 Language

These specifications and associated assessment materials are in English only.

6.8 Disability Discrimination Act Information Relating to these Specifications

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 *Access Arrangements and Special Consideration Regulations and Guidance Relating to Candidates who are Eligible for Adjustments in Examinations* produced by the Joint Council (refer to Section 5.9 of this specification).

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.

Practical assistants may be used for manipulating equipment and making observations. Technology may help visually impaired students to take readings and make observations.

Appendix A: Performance Descriptions

Performance descriptions have been created for all GCE subjects. They describe the learning outcomes and levels of attainment likely to be demonstrated by a representative candidate performing at the A/B and E/U boundaries for AS and A2.

In practice most candidates will show uneven profiles across the attainments listed, with strengths in some areas compensating in the award process for weaknesses or omissions elsewhere. Performance descriptions illustrate expectations at the A/B and E/U boundaries of the AS and A2 as a whole; they have not been written at unit level.

Grade A/B and E/U boundaries should be set using professional judgement. The judgement should reflect the quality of candidates' work, informed by the available technical and statistical evidence. Performance descriptions are designed to assist examiners in exercising their professional judgement. They should be interpreted and applied in the context of individual specifications and their associated units. However, performance descriptions are not designed to define the content of specifications and units.

The requirement for all AS and A level specifications to assess candidates' quality of written communication will be met through one or more of the assessment objectives.

The performance descriptions have been produced by the regulatory authorities in collaboration with the awarding bodies.

AS performance descriptions for chemistry

	Assessment Objective 1	Assessment Objective 2	Assessment Objective 3
Assessment Objectives	**Knowledge and understanding of science and of How Science Works** Candidates should be able to: • recognise, recall and show understanding of scientific knowledge; • select, organise and communicate relevant information in a variety of forms.	**Application of knowledge and understanding of science and of How Science Works** Candidates should be able to: • analyse and evaluate scientific knowledge and processes; • apply scientific knowledge and processes to unfamiliar situations including those related to issues; • assess the validity, reliability and credibility of scientific information.	**How Science Works** Candidates 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; • analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.
A/B boundary Performance Descriptions	Candidates characteristically: a) demonstrate knowledge and understanding of most principles, concepts and facts and from the AS specification; b) select relevant information from the AS specification; c) organise and present information clearly in appropriate forms; d) write equations for most straightforward reactions using scientific terminology.	Candidates characteristically: a) apply principles and concepts in familiar and new contexts involving only a few steps in the argument; b) describe significant trends and patterns shown by data presented in tabular or graphical form; interpret phenomena with few errors; and present arguments and evaluations clearly; c) comment critically on statements, conclusions or data; d) carry out accurately most structured calculations specified for AS; e) use a range of chemical equations f) translate successfully data presented as prose, diagrams, drawings, tables or graphs from one form to another.	Candidates characteristically: a) devise and plan experimental and investigative activities, selecting appropriate techniques; b) demonstrate safe and skilful practical techniques; c) make observations and measurements with appropriate precision and record these methodically; d) interpret, explain, evaluate and communicate the results of their own and others' experimental and investigative activities, in appropriate contexts.

E/U boundary Performance Descriptions	Candidates characteristically: a) demonstrate knowledge and understanding of some principles and facts from the AS specification; b) select some relevant information from the AS specification; c) present information using basic terminology from the AS specification; d) write equations for some straightforward reactions.	Candidates characteristically: a) apply a given principle to material presented in familiar or closely related contexts involving only a few steps in the argument; b) describe some trends or patterns shown by data presented in tabular or graphical form; c) identify, when directed, inconsistencies in conclusions or data; d) carry out some steps within calculations e) use simple chemical equations; f) translate data successfully from one form to another, in some contexts.	Candidates characteristically: a) devise and plan some aspects of experimental and investigative activities; b) demonstrate safe practical techniques; c) make observations and measurements and record them; d) interpret, explain and communicate some aspects of the results of their own and others' experimental and investigative activities, in appropriate contexts.

A2 performance descriptions for chemistry

	Assessment Objective 1	Assessment Objective 2	Assessment Objective 3
Assessment Objectives	**Knowledge and understanding of science and of How Science Works** Candidates should be able to: • recognise, recall and show understanding of scientific knowledge; • select, organise and communicate relevant information in a variety of forms.	**Application of knowledge and understanding of science and of How Science Works** Candidates should be able to: • analyse and evaluate scientific knowledge and processes • apply scientific knowledge and processes to unfamiliar situations including those related to issues; • assess the validity, reliability and credibility of scientific information.	**How Science Works** Candidates 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; • analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.
A/B boundary Performance Descriptions	Candidates characteristically: a) demonstrate detailed knowledge and understanding of most principles, concepts and facts from the A2 specification; b) select relevant information from the A2 specification; c) organise and present information clearly in appropriate forms using scientific terminology; d) write equations for most chemical reactions.	Candidates characteristically: a) apply principles and concepts in familiar and new contexts involving several steps in the argument; b) describe significant trends and patterns shown by complex data presented in tabular or graphical form; interpret phenomena with few errors; and present arguments and evaluations clearly; c) evaluate critically the statements, conclusions or data; d) carry out accurately complex calculations specified for A level; e) use chemical equations in a range of contexts; f) translate successfully data presented as prose, diagrams, drawings, tables or graphs, from one form to another; g) select a wide range of facts, principles and concepts from both AS and A2 specifications; h) link together appropriate facts principles and concepts from different areas of the specification.	Candidates characteristically: a) devise and plan experimental and investigative activities, selecting appropriate techniques; b) demonstrate safe and skilful practical techniques; c) make observations and measurements with appropriate precision and record these methodically; d) interpret, explain, evaluate and communicate the results of their own and others' experimental and investigative activities, in appropriate contexts.

E/U boundary Performance Descriptions	Candidates characteristically: a) demonstrate knowledge and understanding of some principles and facts from the A2 specification; b) select some relevant information from the A2 specification; c) present information using basic terminology from the A2 specification; d) write equations for some chemical reactions.	Candidates characteristically: a) apply given principles or concepts in familiar and new contexts involving a few steps in the argument; b) describe, and provide a limited explanation of, trends or patterns shown by complex data presented in tabular or graphical form; c) identify, when directed, inconsistencies in conclusions or data; d) carry out some steps within calculations; e) use some chemical equations; f) translate data successfully from one form to another, in some contexts; g) select some facts, principles and concepts from both AS and A2 specifications; h) put together some facts, principles and concepts from different areas of the specification.	Candidates characteristically: a) devise and plan some aspects of experimental and investigative activities; b) demonstrate safe practical techniques; c) make observations and measurements and record them; d) interpret, explain and communicate some aspects of the results of their own and others' experimental and investigative activities, in appropriate contexts.

Appendix B: Guidance for Internally Assessed Units

AS Unit F333: *Chemistry in Practice*

Introduction

This unit is teacher assessed and externally moderated by OCR.

Candidates are assessed in **five** skill areas. Teachers assess the ability of candidates to:

- **Skill I (Competence)** – carry out practical work competently and safely using a range of techniques;
- **Skill II (Measurement)** – carry out quantitative experiments accurately and make and record reliable and valid measurements with appropriate accuracy and precision;
- **Skill III (Analysis and evaluation)** – apply chemical knowledge and processes to unfamiliar situations to analyse and evaluate their own quantitative experiments;
- **Skill IV (Observation)** – make and record valid qualitative observations with appropriate accuracy and detail;
- **Skill V (Interpretation)** – recognise, recall and show understanding of chemical knowledge to interpret and explain their own qualitative experiments, with due regard to spelling, punctuation and grammar and correct use of technical terms.

Skill I is assessed over a period of time using a minimum of **six** different practical activities.

Skills II, III, IV and V may be assessed in separate activities or they may be assessed together in **two** separate activities as follows: Skills II and III; Skills IV and V. These activities are provided by OCR. Activity sheets from the course material should **not** be used for assessment.

Award of Marks

Marks for skill I are awarded by direct observation by the teacher of the practical work carried out by candidates over a period of time. Marks are awarded in this skill area using generic descriptors provided by OCR (page 60).

Skills II, III, IV and V are assessed using activities and mark schemes provided by OCR (available *via* download from the OCR Interchange site) and carried out under the direct supervision of the teacher. Marks are awarded in these skill areas using activity specific mark schemes provided by OCR.

Each skill area is assessed by the teacher and given a mark between 0 and 12 to give a final mark out of 60 for this unit which is submitted to OCR.

Skill Area I (Competence)

Candidates carry out a range of practical work over time as a normal and integral part of their study of chemistry. The practical activities **must** provide opportunities for the candidate to:

- carry out a titration;
- make thermochemical measurements;
- carry out qualitative experiments using test-tubes;
- carry out an experiment involving ICT;
- prepare an organic compound;
- collaborate with other students in solving a problem.

Teachers assess the ability of candidates to carry out practical work competently and safely using a range of techniques by direct observation and by matching achievement against the following descriptors:

Marks	Descriptors
1	**Works safely some of the time.** **Demonstrates competent manipulative skills only in basic practical procedures (eg heating, transferring solids and liquids) and does not resolve problems without help.** **Demonstrates a haphazard and disorganised approach to practical work, takes little care when making measurements or observations and pays little attention to detail.**
2	
3	**Works safely for much of the time.** **Demonstrates competent manipulative skills in some of the more demanding practical procedures (eg weighing, use of pipette or burette) and resolves some minor problems without help.** **Demonstrates a reasonable degree of organisation in approach to practical work and makes many measurements and observations carefully and pays attention to some of the detail.**
4	**Works safely most of the time.** **Demonstrates competent manipulative skills in most of the more demanding practical procedures (eg weighing, use of pipette or burette) and resolves most minor problems without help.** **Demonstrates a good degree of organisation in approach to practical work and makes most measurements and observations carefully and pays attention to much of the detail.**
5	
6	**Works safely all of the time.** **Demonstrates well developed manipulative skills in all practical procedures and resolves most problems without help.** **Demonstrates a highly organised approach to practical work and makes all measurements and observations with great care and attention to detail.**

The descriptors should be applied in a 'best fit' manner to choose a mark between 0 and 6 which <u>**best**</u> describes the work of the candidate **over the whole range of practical activities** and takes account, if appropriate, of a higher level of achievement in some of the characteristics within the descriptors and a lower level of achievement in other characteristics. A mark of 0 should be awarded if the descriptors are not met in any way.

It is expected that there will be a broad match between the mark awarded for skill I and the evidence available from the assessment of skills II and IV ***and moderators will check for this match.***

Teachers must keep a record of the candidates' achievement over time in a working document, a specimen of which will be supplied by OCR. Teachers should use this document to help them award a mark between 0 and 6 which best describes the candidates' average level of achievement in this skill area.

This mark is then doubled to give a mark out of 12 to match those for skill areas II–V.

Skill Areas II (Measurement), III (Analysis and evaluation), IV (Observation) and V (Interpretation).

The assessment of skill areas II, III, IV and V is made using activities and specific mark schemes provided by OCR. These activities must be carried out individually under controlled conditions supervised by the teacher.

Skill areas II, III, IV and V may be assessed using separate activities.

Skill areas II and III may be assessed using a single activity in which the candidate makes, records, analyses and evaluates quantitative measurements.

Skill areas IV and V may be assessed using a single activity in which the candidate makes, records, interprets and explains qualitative observations.

Where a skill area is assessed on more than one occasion, only the best mark should be reported.

Moderation

Teachers must supply the following documentation for external moderation purposes:

- an F333 – Skill I (Competence) – Experiment Description and Mark Sheet used to describe the activities on which the mark for skill area I is based and to record marks in this skill area. This will be supplied by OCR;
- an F333 Skill Area Mark Sheet completed to show the marks awarded in each skill area for each candidate. This will be supplied by OCR;
- details of the activities on which the award of marks in skill areas II, III, IV and V is based;
- candidates' work on which the award of marks in skill areas II, III, IV and V is based for those candidates in the moderation sample.

This unit is teacher assessed and externally moderated by OCR.

Candidates carry out a single individual investigation. The topic may be taken from any aspect of chemistry. Candidates are expected to spend **about 18 hours** in the laboratory carrying out practical work as part of their investigation, and an **appropriate amount of time both before and after** this period preparing for and using the results of their investigation.

Candidates are assessed in **eight** skill areas (A–H). Teachers assess the ability of candidates to:

Skill Area A (Chemical ideas) – apply scientific knowledge and processes to unfamiliar situations (6 marks);

Skill Area B (Methods) – select and describe appropriate qualitative and quantitative methods (6 marks);

Skill Area C (Communication) – select, organise and communicate relevant information with due regard to spelling, punctuation and grammar and the accurate use of specialist vocabulary (5 marks);

Skill Area D (Observations and measurements) – make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy (6 marks);

Skill Area E (Analysis and interpretation) – analyse and interpret the results of investigative activities (6 marks);

Skill Area F (Evaluation) – explain and evaluate the methodology and results of investigative activities (6 marks);

Skill Area G (Manipulation) – demonstrate safe and skilful practical techniques and processes (5 marks);

Skill Area H (Demand) – develop and apply familiar and new chemical knowledge and processes in demanding situations (5 marks).

The marks for the eight skill areas are added together to provide a mark out of 45 for this unit which is submitted to OCR.

Authentication and marking of candidates' work.

Candidates must complete and hand in their investigation report in **three separate sections**. Teachers must verify that, to the best of their knowledge, **each section is the work of the candidate concerned.**

Section 1 of the investigation report (teacher marks skills A–C)

Candidates must complete and hand in a first draft of section 1 of their investigation report **before they begin** any practical work. **This draft should be authenticated by the teacher** and returned to the candidate so that it can be revisited and modified as the investigation proceeds. The final draft of this section should be taken in by the teacher for final marking as soon as practical work has been completed.

In this section candidates should:

- identify and describe the aims of the investigation;
- describe the chemical knowledge which they have researched in order to help them devise their investigation plan;
- describe the equipment, materials and experimental procedures they use to achieve the investigation aims;
- include a risk assessment;
- include a list of references to sources they have consulted to help them devise their plan.

In all of these, candidates should be careful to use technical terms correctly and pay careful attention to spelling, punctuation and grammar.

Teachers award marks using generic criteria in three skill areas (A, B and C). In each area the marks are awarded by applying a 'best fit' approach to match the candidate's work against criteria.

Skill Area A (Chemical ideas) – apply scientific knowledge and processes to unfamiliar situations (6 marks).

Skill Area B (Methods) – select and describe appropriate qualitative and quantitative methods (6 marks).

Skill Area C (Communication) – select, organise and communicate relevant information with due regard to spelling, punctuation and grammar and the accurate use of specialist vocabulary (5 marks).

Section 2 of the investigation report (teacher marks skill D)

Candidates must complete and hand in section 2 of their investigation report as soon as they have completed their practical work. This section should be authenticated by the teacher. Candidates are expected to retain a copy of this section to allow them to interpret and evaluate the results of their investigation.

In this section candidates should:

- Record the observations and measurements made during the investigation, taking care that there are a sufficient number of good quality measurements and/or observations that are presented clearly.

Teachers award marks using generic criteria in one skill area (D). In this area the marks are awarded by applying a 'best fit' approach to match the candidates' work against criteria.

Skill Area D (Observations and measurements) – make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy (6 marks).

Section 3 of the investigation report (teacher marks skills E and F)

Candidates must complete and hand in section 3 of their investigation report after they have been given time to analyse, interpret and evaluate their investigation. **This section should be authenticated by the teacher.**

In this section candidates should:

- describe the outcomes of their investigation;
- draw together observations and/or manipulate raw data using calculations and graphs;
- interpret observations and measurements;
- draw conclusions from raw and/or manipulated data and observations using underlying chemical knowledge;
- comment on the limitations of practical procedures;
- calculate, where appropriate, the experimental uncertainty associated with measurements;
- evaluate the choices of equipment, materials and practical procedures used in the investigation;

Teachers award marks using generic criteria in two skill areas (E and F). In each skill area the marks are awarded by applying a 'best fit' approach to match the candidates' work against the criteria.

Additional skill areas (G and H)

In addition to the six skill areas described above, teachers award marks in two further areas (G and H) using generic criteria. In both skill areas, marks are awarded by applying a 'best fit' approach to match the candidates' work against the criteria.

Marks for these two skill areas must be awarded soon after the completion of practical work.

The practical work undertaken by the candidate must be supervised by the teacher who will assess skill area G. In addition, teachers must keep a record as a working document of their observation of the candidates' ability to carry out practical work safely and skilfully.

The teacher will assess the ability of the candidate to:

- work safely;
- manipulate equipment and materials;
- make observations and take measurements.

In skill area H teachers assess the demand of the investigation undertaken by the candidate.

Teachers take account of the demand arising from the candidate:

- using unfamiliar equipment and chemical ideas;
- using experimental procedures in unfamiliar situations;
- using chemical ideas in unfamiliar situations;
- devising innovative experimental procedures;
- solving emerging problems.

Detailed Mark Schemes

For each skill shown in the tables that follow, the descriptors below should be applied in a 'best fit' manner to choose a mark between 1 and 5 or 6 which **best** describes the work of the candidate and takes account, if appropriate, of a higher level of achievement in some of the characteristics within the descriptors and a lower level of achievement in other characteristics. This should be achieved by selecting the descriptors at each level which provide the best match with different aspects of the candidates' work. A mark of 0 should be awarded if the descriptors are not met in any way.

Moderation of Candidates' Work

Where candidates are assessed by different teachers in a centre, a system of internal moderation must be devised and used to ensure that exactly the same standards are used in the award of marks for all candidates. A recommended method would involve all teachers in the centre marking the work of a selection of candidates at the start of the moderation process to establish the standards to be applied to the work of all candidates.

The work of candidates will also be subject to external moderation by OCR.

Teachers must supply the following documentation for external moderation purposes:

- a completed mark record form showing the marks awarded in each skill area for each candidate. This will be supplied by OCR;
- the working document used by teachers to help award an appropriate mark in skill area G.

Sections 1, 2 and 3 of the candidates' final investigation report on which the award of marks is based for those candidates in the moderation sample.

Marks	Descriptors for Skill A (Chemical ideas) (6 marks)	Descriptors for Skill B (Methods) (6 marks)
	Apply chemical knowledge and processes to unfamiliar situations. (range, depth, accuracy)	Select and describe appropriate qualitative and quantitative methods. (aims, choices, descriptions)
1	Describes a small range of basic chemical knowledge in support of the investigation. Describes chemical knowledge superficially and includes few details. Makes errors in using chemical knowledge and describes chemical knowledge which is not relevant to the actual investigation undertaken.	Identifies and defines the aims of the investigation in a vague or unclear manner. Selects equipment and materials and devises experimental procedures that are sometimes inappropriate to achieve the aims of the investigation. Describes in limited detail the experimental procedures used.
3	Describes a wide range of chemical knowledge in support of the investigation. Describes chemical knowledge in some depth and includes many details. Makes a few errors when describing chemical knowledge and describes chemical knowledge which is generally relevant to the actual investigation undertaken.	Identifies and defines the aims of the investigation in a generally precise and clear manner. Selects equipment and materials and devises experimental procedures that are generally appropriate to achieve the aims of the investigation. Describes, including most appropriate detail, experimental procedures used.

Marks	Descriptors for Skill A (Chemical ideas) (6 marks)	Descriptors for Skill B (Methods) (6 marks)
	Apply chemical knowledge and processes to unfamiliar situations. (range, depth, accuracy)	Select and describe appropriate qualitative and quantitative methods. (aims, choices, descriptions)
6	Describes a comprehensive range of chemical knowledge in support of the investigation. Describes chemical knowledge in great depth and includes all appropriate details. Describes chemical knowledge without errors and describes chemical knowledge which is fully relevant to the actual investigation undertaken.	Identifies and defines the aims of the investigation in a very precise and clear manner. Selects equipment and materials and devises experimental procedures that are fully appropriate to achieve the aims of the investigation. Describes in fine detail the experimental procedures used.

Intermediate marks should be awarded to provide the best match between a candidate's performance and the descriptors.

Marks	Descriptors for Skill D (Observation and measurements) (6 marks)	Descriptors for Skill E (Analysis and interpretation) (6 marks)	Descriptors for Skill F (Evaluation) (6 marks)
	Make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy. (results: number, range, quality, clarity)	Analyse and interpret the results of investigative activities. (outcomes, calculations, graphs, interpretation of observations, conclusions)	Explain and evaluate the methodology and results of investigative activities. (limitations of procedures, reliability and validity of observations, uncertainty associated with measurements, equipment and procedure choice)
1	Records significantly fewer observations and/or measurements than are appropriate for the particular investigation undertaken and records a limited range of observations and/or measurements. Records observations that are vague, lack detail or are inappropriate and/or measurements that are imprecise, of poor quality or lack appropriate units. Records observations and/or measurements in a haphazard, unclear or disorganised format which make it difficult to understand them.	Describes the outcomes of the investigation in basic terms only. Makes little effective use of observations to support conclusions and/or makes little progress in calculations or draws poor quality or inappropriate graphs from measurements. Makes little use of underlying chemical knowledge to interpret observations and/or measurements and draws basic or superficial conclusions from recorded observations and/or measurements.	Comments briefly and in simple terms on the limitations of practical procedures. Comments briefly and in simple terms on the reliability and validity of observations and/or includes calculations of the uncertainty associated with measurements that are of limited range or inaccurate. Comments briefly in descriptive rather than evaluative terms on the choices made of materials, equipment and practical procedures used in the investigation.
3	Records most appropriate observations and/or measurements for the particular investigation undertaken, and records a wider range of observations and/or measurements. Records observations that are often precise, detailed and appropriate and/or measurements that are generally precise, of good quality and include appropriate units. Records observations and/or measurements in a generally clear and organised format which make it possible to understand them with little difficulty.	Describes the outcomes of the investigation in reasonable detail. Makes reasonably effective use of observations to support conclusions and/or generally uses calculations effectively and draws graphs from measurements which are generally of good quality and appropriate. Makes quite good use of underlying chemical knowledge to interpret observations and/or measurements and draws conclusions from recorded observations and/or measurements which are in some detail and depth.	Comments on some of the key limitations of practical procedures. Comments in reasonable detail on the reliability and validity of observations and/or includes calculations of the uncertainty associated with measurements that include a range of different types and are generally accurate. Evaluates in reasonable detail the choices made of materials, equipment and practical procedures used in the investigation.

Marks	Descriptors for Skill D (Observation and measurements) (6 marks)	Descriptors for Skill E (Analysis and interpretation) (6 marks)	Descriptors for Skill F (Evaluation) (6 marks)
	Make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy. (results: number, range, quality, clarity)	Analyse and interpret the results of investigative activities. (outcomes, calculations, graphs, interpretation of observations, conclusions)	Explain and evaluate the methodology and results of investigative activities. (limitations of procedures, reliability and validity of observations, uncertainty associated with measurements, equipment and procedure choice)
6	Records all appropriate observations and/or measurements for the particular investigation undertaken and records a wide range of observations and/or measurements to investigate the chosen topic effectively. Records observations that are precise, detailed and appropriate and/or measurements that are precise, of good quality and include appropriate units. Records observations and/or measurements in a clear and organised format which make it easy to understand them.	Describes the outcomes of the investigation in full detail. Makes very effective use of observations to support conclusions and/or uses calculations effectively and draws graphs from measurements which are all of good quality and appropriate. Makes comprehensive and effective use of underlying chemical knowledge to interpret observations and/or measurements and draws conclusions from recorded observations and/or measurements which are in considerable detail and depth.	Comments on all of the expected limitations of practical procedures. Comments in full detail on the reliability and validity of observations and/or includes accurate calculations of the uncertainty associated with all types of measurements recorded. Fully evaluates the choices made of materials, equipment and practical procedures used in the investigation.

Intermediate marks should be awarded to provide the best match between a candidate's performance and the descriptors.

Marks	Descriptors for Skill C (Communication) (5 marks)	Descriptors for Skill G (Manipulation) (5 marks)	Descriptors for Skill H (Demand) (5 marks)
	Select, organise and communicate relevant information. (risk assessment, references, clarity, vocabulary, QWC)	Demonstrates safe and skilful techniques and processes. (safety, manipulative skills, organisation)	Develop and apply familiar and new chemical knowledge and processes in demanding situations. (procedures, chemical ideas, innovation/creativity)
1	Includes a risk assessment which covers only some of the hazards, contains much material which is not relevant to the investigation undertaken, is superficial and is inaccurate. Includes a list of references which is linked to a narrow range of sources and which lacks detail about the sources. Produces an account which is unclear and is difficult to understand, in which specialist vocabulary is used inappropriately and in which spelling of technical terms is frequently inaccurate.	Works safely some of the time. Demonstrates competent manipulative skills in basic practical procedures and resolves problems with help. Some aspects of the approach to practical work are organised, takes some care when making observations and/or measurements and pays some attention to detail.	The level of demand in the investigation is low because: Experimental procedures cover activities undertaken as a normal part of the chemistry course; Chemical ideas which have been met before are used in familiar situations; There is some limited evidence of innovation or creativity in devising experimental procedures and/or, if appropriate, in solving emerging problems.
3	Includes a risk assessment which covers most hazards, contains material which is generally relevant to the investigation undertaken, is in some detail and is generally accurate. Includes a list of references which is linked to a fairly wide range of sources and which includes some detail about the sources. Produces an account which is generally clear and is generally easy to understand, in which specialist vocabulary is used appropriately most of the time, and in which spelling of technical terms is generally accurate.	Works safely most of the time. Demonstrates competent manipulative skills in a wide range of practical procedures and resolves minor problems without help. Demonstrates a reasonable degree of organisation in approach to practical work, makes most observations and/or measurements carefully and pays attention to some of detail most of the time.	The level of demand in the investigation is intermediate because: Experimental procedures extend beyond activities undertaken as a normal part of the chemistry course and are used in new situations; Chemical ideas which have been met before are used in new situations; There is some evidence of innovation or creativity in devising experimental procedures and/or, if appropriate, in solving emerging problems.

Marks	Descriptors for Skill C (Communication) (5 marks)	Descriptors for Skill G (Manipulation) (5 marks)	Descriptors for Skill H (Demand) (5 marks)
	Select, organise and communicate relevant information. (risk assessment, references, clarity, vocabulary, QWC)	Demonstrates safe and skilful techniques and processes. (safety, manipulative skills, organisation)	Develop and apply familiar and new chemical knowledge and processes in demanding situations. (procedures, chemical ideas, innovation/creativity)
5	Includes a risk assessment which covers all hazards, contains material all of which is relevant to the investigation undertaken, contains full details and is accurate. Includes a list of references which is linked to a comprehensive and appropriate range of sources which includes detail about the sources linked effectively to specific parts of the written account. Produces an account which is very clear and easy to understand, in which specialist vocabulary is used appropriately all of the time and in which spelling of technical terms is accurate.	Works safely all of the time. Demonstrates highly developed manipulative skills in all practical procedures and resolves most problems without help. Demonstrates a highly organised approach to practical work, makes all observations and/or measurements with great care and pays great attention to detail.	The level of demand in the investigation is high because: Experimental procedures used in the investigation have not been previously met or are familiar procedures which are developed and used in new and unfamiliar situations; Chemical ideas used in the investigation have not been previously met or are familiar ideas which are developed and used in new and unfamiliar situations; There is clear evidence of innovation or creativity in devising experimental procedures and/or, if appropriate, in solving emerging problems.

Intermediate marks should be awarded to provide the best match between a candidate's performance and the descriptors.

Appendix C: Development of 'How Science Works'

Candidates will bring their basic understanding of this topic from GCSE and wish to develop it further. The skills, knowledge and understanding of *How Science Works*, summarised in the left-hand column below, will underpin the teaching and assessment contexts of the course. The examples given below give just a taste of what is available.

How Science Works statement	Examples of coverage at AS	Examples of coverage at A2
i Use theories, models and ideas to develop and modify scientific explanations	development of models (illustrated by the theories of the atom); development of Mendeleev's ideas of the Periodic Table (**EL**); limitations of *'dot-and-cross'* diagrams (**EL**); use of reaction mechanisms as models to explain chemical reactions.	the proposal of several models for DNA before the current one (**EP**); models of benzene structure (**CD**).
ii Use knowledge and understanding to pose scientific question, define scientific problems and present scientific arguments and scientific ideas	*many examples of this wide-ranging statement, including:* design simple experiments to measure the energy transferred when reactions occur in solution or flammable liquids burn (**DF**); relate the solubility of a dissolving polymer to its molecular structure (**PR**).	*many examples of this wide-ranging statement, including:* using scientific knowledge and methodology to modify the properties of a polymer (**MR**); Embedded in the criteria for the Chemistry Individual Investigation (F336).
iii Use appropriate methodology, including ICT, to answer scientific questions and solve scientific problems	design simple experiments to measure the energy transferred (**DF**); predict the boiling points of liquids from their molecular structure (**PR**); Embedded in the AS internal assessment unit F333.	suggest procedures for redox and acid–base titrations (**SS**); Embedded in the criteria for the Chemistry Individual Investigation (F336).
iv Carry out experimental and investigative activities, including appropriate risk management, in a range of contexts	preparatory work on the Advance Notice passage for unit F332; Embedded in the AS internal assessment unit F333.	Embedded in the criteria for the Chemistry Individual Investigation (F336).
v Analyse and interpret data to provide evidence, recognising correlations and causal relationships	analysis of IR spectra (**PR**); solving mole calculations (**EL**, **DF**, **ES**); Embedded in the AS internal assessment unit F333.	solve unstructured titration problems (**SS**); analyse IR NMR and mass spectra (**MD**); Embedded in the criteria for the Individual Investigation (F336).
vi Evaluate methodology, evidence and data and resolve conflicting evidence	Embedded in the AS internal assessment unit F333; evaluation of experiments to measure enthalpy changes (**DF**); resolve the conflicting evidence from research on the ozone hole (**A**).	Embedded in the criteria for the Chemistry Individual Investigation (F336).

vii Appreciate the tentative nature of scientific knowledge	development of models (eg atomic theory) and Mendeleev's ideas show the tentative nature of scientific knowledge (**EL**).	development of models of DNA and benzene (**EP**, **CD**).
viii Communicate information and ideas in appropriate ways using appropriate terminology	*many examples including:* explain the 'greenhouse effect' in the troposphere and relate it to the absorption characteristics of atmospheric gases and global warming (**A**); explain the mechanism of the electrophilic addition reaction between electrophiles and alkenes (**PR**).	*many examples including:* describe the origins of colour in transition metal compounds or organic molecules (**CD**).
ix Consider applications and implications of science and their associated risks	benefits and risks of radioactive tracers (**EL**); risks of pollutants from car petrol and the benefits of developing better fuels (**DF**); risks of handling the halogens set against the benefits of uses of their compounds (**ES**); the benefits and risks to us and the environment of CFCs and their replacements (**A**).	balance the benefits and risks of the manufacture and disposal of polymers (**MR**); the hazards of the chemical industry balanced against its benefits (**AI**); implications of methods of disposing of carbon dioxide (**O**).
x Consider ethical issues in the treatment of humans, other organisms and the environment	the effect on the environment of car pollutants (**DF**); sustainability issues in the chemical industry (**ES**); CFCs and greenhouse gases (**A**).	the use of enzymes in green chemistry (**TL**); the ethics of storing DNA data (**TL**); the ethics of testing medicines (**TL**, **MD**); the effects of industrial processes on the environment; the ethics of using chemicals in agriculture (**AI**).
xi Appreciate the role of the scientific community in validating new knowledge and ensuring integrity	the scientific community validating Mendeleev's work on the Periodic Table (**EL**); why the evidence for the 'ozone hole' was overlooked (**A**).	making new compounds and testing for medicinal effect (**WM**, **MD**).
xii Appreciate ways in which society uses science to inform decision-making	informing society of the risks of pollutants from various fuels (**DF**); the ways in which society's decision making has been informed by science in the matters of the ozone hole and global warming (**A**).	balance the benefits and risks of the manufacture and disposal of polymers and inform society of these (**MR**); the ethics of storing DNA data (**EP**); informing the public about medicine use and safety (**WM**, **MD**); the ethics of using chemicals in agriculture (**AI**).

Data Sheet for Chemistry B (Salters)

(version 2.0)

OCE/10218

GCE Advanced Level and Advanced Subsidiary

Chemistry B (Salters) (H035, H435)

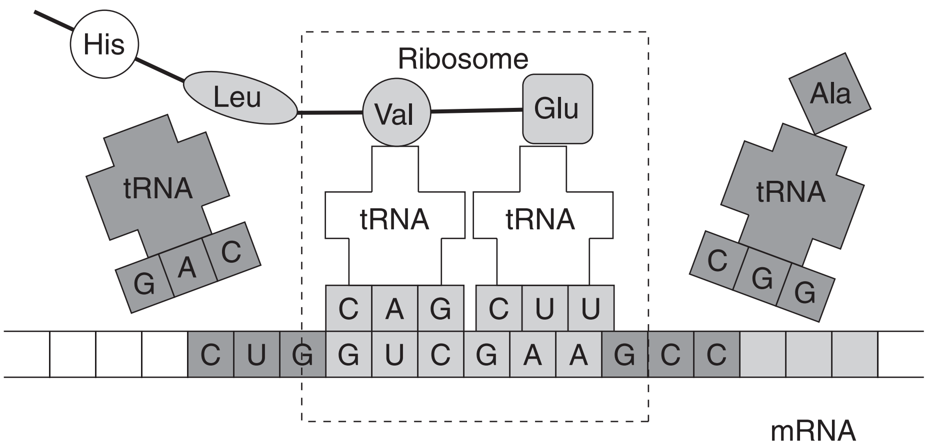
Chemistry units F331–F336

The information in this sheet is for the use of candidates following Chemistry B (Salters) H035 and H435

A copy of this sheet will be included as an insert with each unit paper.

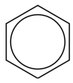
Copies of this sheet may be used for teaching.

Diagram to illustrate protein synthesis



ADAPTED FROM SALTERS' ADVANCED CHEMISTRY: CHEMICAL STORYLINES BY GEORGE BURTON. REPRINTED BY PERMISSION OF HARCOURT EDUCATION

Characteristic infrared absorption in organic molecules

bond	location	wavenumber/cm^{-1}	intensity	
C—H	alkanes	2850–2950	M–S	M medium
	alkenes, arenes	3000–3100	M–S	S strong
	alkynes	*ca.* 3300	S	* hydrogen bonded
C═C	alkenes	1620–1680	M	
	arenes	several peaks in range 1450–1650	variable	
C≡C	alkynes	2100–2260	M	
C═O	aldehydes	1720–1740	S	
	ketones	1705–1725	S	
	carboxylic acids	1700–1725	S	
	esters	1735–1750	S	
	amides	1630–1700	M	
C—O	alcohols, ethers, esters	1050–1300	S	
C≡N	nitriles	2200–2260	M	
C—F	fluoroalkanes	1000–1400	S	
	chloroalkanes	600–800	S	
	bromoalkanes	500–600	S	
O—H	alcohols, phenols	3600–3640	S	
	*alcohols, phenols	3200–3600	S (broad)	
	*carboxylic acids	2500–3200	M (broad)	
N—H	primary amines	3300–3500	M–S	
	amides	*ca.* 3500	M	

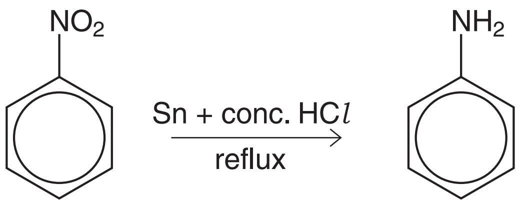
Some useful organic reactions

1 $R{-}Br + CN^- \longrightarrow R{-}CN + Br^-$

2 $R{-}CN \xrightarrow[\text{reflux}]{H^+(aq)/H_2O} R{-}COOH$

3 $RCHO \xrightarrow{NaBH_4} RCH_2OH$

4 $RR'C{=}O \xrightarrow{NaBH_4} RR'CH{-}OH$

5 

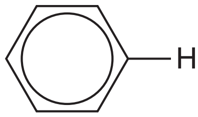
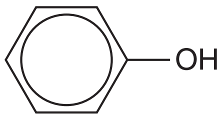
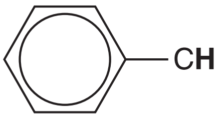
6 $R{-}COOH + SCl_2O \longrightarrow R{-}COCl + SO_2 + HCl$

7 $R{-}OH \xrightarrow{NaBr/\ c.H_2SO_4} R{-}Br$

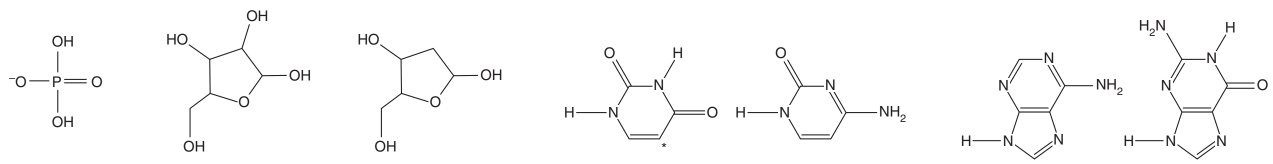
Chemical shifts for some types of protons (^1H) in NMR spectra

Chemical shifts are for hydrogen (^1H) relative to TMS (tetramethylsilane).

They are typical values and can vary slightly depending on the solvent, concentration and substituents.

type of proton	chemical shift, *δ*/ppm	type of proton	chemical shift, *δ*/ppm
$C\mathbf{H}_3$—C	0.7–1.6		6.4–8.2
C—C$\mathbf{H}_2$—C C—C**H**(—C)—C	1.4–2.3	—C—C**H**O	9.4–10.0
>C**H**—C(=O)— carbonyls, esters, amides, acids	2.0–2.7	—C—O**H**	0.5–4.5*
—C**H**—N amines, amides	2.3–2.9		4.5–10.0*
	2.3–3.0	—C—N**H**	1.0–5.0*
—O—C**H** alcohols, esters, ethers	3.3–4.8	—CO—N**H**	5.0–12.0*
—C**H**—C*l* or Br	3.0–4.2	—CO—O**H**	9.0–15.0*
—C**H**═C**H**—	4.5–6.0	*these signals are *very* variable (sometimes outside these limits) and often broad.	

Monomers of DNA and RNA



phosphate **ribose** **deoxyribose** **uracil** **cytosine** **adenine** **guanine**

(thymine has a CH_3 at position *)

The Periodic Table of the Elements

Key

relative atomic mass **atomic symbol** name atomic (proton) number

1	2											3	4	5	6	7	0
							1.0 **H** hydrogen 1										4.0 **He** helium 2
6.9 **Li** lithium 3	9.0 **Be** beryllium 4											10.8 **B** boron 5	12.0 **C** carbon 6	14.0 **N** nitrogen 7	16.0 **O** oxygen 8	19.0 **F** fluorine 9	20.2 **Ne** neon 10
23.0 **Na** sodium 11	24.3 **Mg** magnesium 12											27.0 **Al** aluminium 13	28.1 **Si** silicon 14	31.0 **P** phosphorus 15	32.1 **S** sulfur 16	35.5 **Cl** chlorine 17	39.9 **Ar** argon 18
39.1 **K** potassium 19	40.1 **Ca** calcium 20	45.0 **Sc** scandium 21	47.9 **Ti** titanium 22	50.9 **V** vanadium 23	52.0 **Cr** chromium 24	54.9 **Mn** manganese 25	55.8 **Fe** iron 26	58.9 **Co** cobalt 27	58.7 **Ni** nickel 28	63.5 **Cu** copper 29	65.4 **Zn** zinc 30	69.7 **Ga** gallium 31	72.6 **Ge** germanium 32	74.9 **As** arsenic 33	79.0 **Se** selenium 34	79.9 **Br** bromine 35	83.8 **Kr** krypton 36
85.5 **Rb** rubidium 37	87.6 **Sr** strontium 38	88.9 **Y** yttrium 39	91.2 **Zr** zirconium 40	92.9 **Nb** niobium 41	95.9 **Mo** molybdenum 42	[98] **Tc** technetium 43	101.1 **Ru** ruthenium 44	102.9 **Rh** rhodium 45	106.4 **Pd** palladium 46	107.9 **Ag** silver 47	112.4 **Cd** cadmium 48	114.8 **In** indium 49	118.7 **Sn** tin 50	121.8 **Sb** antimony 51	127.6 **Te** tellurium 52	126.9 **I** iodine 53	131.3 **Xe** xenon 54
132.9 **Cs** caesium 55	137.3 **Ba** barium 56	138.9 **La*** lanthanum 57	178.5 **Hf** hafnium 72	180.9 **Ta** tantalum 73	183.8 **W** tungsten 74	186.2 **Re** rhenium 75	190.2 **Os** osmium 76	192.2 **Ir** iridium 77	195.1 **Pt** platinum 78	197.0 **Au** gold 79	200.6 **Hg** mercury 80	204.4 **Tl** thallium 81	207.2 **Pb** lead 82	209.0 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	Elements with atomic numbers 112–116 have been reported but not fully authenticated						

140.1 **Ce** cerium 58	140.9 **Pr** praseodymium 59	144.2 **Nd** neodymium 60	144.9 **Pm** promethium 61	150.4 **Sm** samarium 62	152.0 **Eu** europium 63	157.2 **Gd** gadolinium 64	158.9 **Tb** terbium 65	162.5 **Dy** dysprosium 66	164.9 **Ho** holmium 67	167.3 **Er** erbium 68	168.9 **Tm** thulium 69	173.0 **Yb** ytterbium 70	175.0 **Lu** lutetium 71
232.0 **Th** thorium 90	[231] **Pa** protactinium 91	238.1 **U** uranium 92	[237] **Np** neptunium 93	[242] **Pu** plutonium 94	[243] **Am** americium 95	[247] **Cm** curium 96	[245] **Bk** berkelium 97	[251] **Cf** californium 98	[254] **Es** einsteinium 99	[253] **Fm** fermium 100	[256] **Md** mendelevium 101	[254] **No** nobelium 102	[257] **Lr** lawrencium 103

Appendix E: Course Publications

Four publications provide comprehensive coverage of the Chemistry B (Salters) course for candidates and teachers. All are endorsed by OCR and published by Harcourt.

- The ***Chemical Storylines*** (published as an AS and an A2 volume) provide the chemical contexts (many of them contemporary) within which chemical ideas and skills are developed.

- The ***Chemical Ideas*** systematically draw together the chemical principles from different parts of the course.

- The ***Activities and Assessment pack*** with the ***Teachers' and Technician guide*** is a loose-leaf file that provides worksheets for practical work, group exercises, data analysis, applications of information technology and so on as well as end of module tests for each of the teaching modules. It also contains guidance on planning, background references notes on activities (for both teachers and technicians) and answers to questions.

Appendix F: Command Words

The command words below are used to start the learning outcomes in the specification. These can be interpreted as follows.

command word	meaning that the candidate should
calculate/work out	use given data to perform a mathematical operation, including recall of any relevant mathematical formulae
compare	describe similarities and differences between given or recalled data
describe	know the facts and be able to write about the phenomenon without giving reasons why it occurs
discuss	know enough examples to give reasons for and against, *unless* the statement says ‘given suitable examples’
draw	be able to draw diagrams/formulae
explain	know the facts and be able to give the chemical reasons for an idea
interpret (equations/ formulae)	be able to explain the meaning of an equation or formula
recall	learn and interpret just what is in the statement
recognise	be able to identify
suggest/predict	apply previous knowledge to an unfamiliar situation
understand	be able to give the reasons for but **not** recall specific detail (*examples* of applications may be given (with an ‘eg’) as illustration; knowledge of these cannot be examined unless the relevant facts are given; if applications are given **without** an ‘eg’, then recall and explanation of these applications can be examined)
use (the term)	understand the context in which the term is met in chemistry
write (equations)	be able to construct and balance equations for given data or recalled reactions
write an expression for	write out a mathematical formula

Appendix G: Procedures for the Advance Notice Article in Unit F332

This will consist of a chemical article relevant to the content of Unit F332.
It will be available for download *via* OCR Interchange at least five weeks before the examination.

The instructions for teachers and candidates that will accompany the Advance Notice article are given below:

Notes for Guidance (candidates)

1. This leaflet contains an article which is needed in preparation for a question in the externally assessed examination F332.

2. You will need to read the article carefully and also have covered the learning outcomes for Unit F332 (Chemistry of Natural Resources). The examination paper will contain questions on the article. You will be expected to apply your knowledge and understanding of the work covered in Unit F332 to answer this question. There are 20 marks available on the paper for this question.

3. You can seek advice from your teacher about the content of the article and you can discuss it with others in your class. You may also investigate the topic yourself using any resources available to you.

4. You will not be able to bring your copy of the article, or other materials, into the examination. The examination paper will contain a fresh copy of the article as an insert.

5. You will not have time to read this article for the first time in the examination if you are to complete the examination paper within the specified time. However, you should refer to the article when answering the questions.

Notes for Guidance (teachers)

1. This Advance Notice material should be issued to candidates on or after the date shown on the front cover of the candidate instructions sheet at the discretion and convenience of the centre. Candidates can be given the material at any point, but it is suggested that this should be at least four weeks before the examination date.

2. Candidates will need to read the article carefully. Time can be built into the teaching programme to introduce the article content. Candidates should be able to discuss the article freely and be given support and advice in the interpretation of the content so that they are able to answer the questions based on the article in the externally assessed examination. Candidates should also be encouraged to investigate the topics covered in the article for themselves.

3. Candidates will be expected to apply their knowledge and understanding of Unit F332 to questions based on the article. There are 20 marks available on the paper for this question.

The Advance Notice material must not be taken into the examination. The examination paper F332 will contain a fresh copy of the article, as an insert. Candidates should be reminded that they do not have sufficient time during the examination to read the article for the first time. They should, however, refer to the article printed in the insert in the examination paper to help them to answer the questions.

Appendix H: Mathematical Requirements

In order to be able to develop their skills, knowledge and understanding in chemistry, students need to have been taught, and to have acquired competence in, the appropriate areas of mathematics relevant to the subject as indicated below.

1 Arithmetic and numerical computation:

(a) recognise and use expressions in decimal and standard form;
(b) use ratios, fractions and percentages;
(c) make estimates of the results of calculations (without using a calculator);
(d) use calculators to find and use power, exponential and logarithmic functions.

2 Handling data:

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

3 Algebra:

(a) understand and use the symbols: $=$, $<$, $\ll$, $\gg$,$>$, $\propto$, $\sim$;
(b) change the subject of an equation;
(c) substitute numerical values into algebraic equations using appropriate units for physical quantities;
(d) solve simple algebraic equations;
(e) use logarithms in relation to quantities which range over several orders of magnitude.

4 Graphs:

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

5 Geometry and trigonometry:

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

Appendix I: Using OCR Interchange to download AS Practical Skills tasks and Advance Notice articles

All materials for the assessment of GCE Chemistry B (Salters) AS Practical Skills (for unit F333) as well as the Advance Notice article (for unit F332) can be obtained from OCR Interchange.

How to use OCR Interchange

OCR Interchange is a secure extranet enabling registered users to administer qualifications on-line. Your Examinations Officer is probably using OCR Interchange to administer qualifications already. If this is not the case, then your centre will need to register.

Your Examinations Officer will be able to:*

- download the relevant documents for you by adding the role of 'Science Coordinator' to their other roles or
- create a new user account for you (adding the Science Coordinator role) so that you can access the GCE Chemistry B (Salters) pages and download documents when you need them.

*Note that in order to assign the role of Science Coordinator to others, the Examinations Officer will need to hold the role of Centre Administrator.

The website address for Interchange is:

https://interchange.ocr.org.uk

The teacher who has downloaded these materials is responsible for ensuring that any pages labelled **confidential** are stored securely so that students do not have the opportunity to access them.

It is intended that the circulation of the AS Practical Tasks and Advance Notice article is limited to those students who are currently undertaking that work. These materials should be photocopied and issued to students at the start of the activity. Numbering the documents may help to keep track of them.

Registering for Interchange

If your Examinations Officer is not already a registered user of Interchange then he/she will need to register before the Chemistry B (Salters) AS Practical Tasks or Advance Notice article can be downloaded.

This is a straightforward process:

- Go to the website – https://interchange.ocr.org.uk.
- The first page has a New User section.
- Click on Sign Up to access the OCR Interchange Agreement Form 1.
- Download this document and fill in your details.
- Return form by post to OCR Customer Contact Centre, Westwood Way, Coventry, CV4 8JQ or fax the form back to 024 76 851633.
- OCR will then contact the Head of Centre with the details needed for the Examinations Officer to access OCR Interchange.

Appendix J: Health and Safety

In UK law, health and safety is the responsibility of the employer. For most establishments entering candidates for AS and Advanced GCE, this is likely to be the local education authority or the governing body. Employees, i.e. teachers and lecturers, have a duty to cooperate with their employer on heal th and safety matters. Various regulations, but especially the COSHH Regulations 2002 and the Management of Health and Safety at Work Regulations 1999, require that before any activity involving a hazardous procedure or harmful micro-organisms is carried out, or hazardous chemicals are used or made, the employer must provide a risk assessment. A useful summary of the requirements for risk assessment in school or college science can be f ound at www.ase.org.uk/htm/teacher_zone/safety_in_science_education.php.

For members, the CLEAPSS® guide, *Managing Risk Assessment in Science** offers detailed advice. Most education employers have adopted a range of nationally available publications as the basis for their Model Risk Assessments. Those commonly used include:

- *Safety in Science Education*, DfEE, 1996, HMSO, ISBN 0 11 270915 X.

  Now out of print but sections are available at:
  www.ase.org.uk/htm/teacher_zone/safety_in_science_education.php;

- *Topics in Safety*, 3rd edition, 2001, ASE ISBN 0 86357 316 9;

- *Safeguards in the School Laboratory*, 11th edition, 2006, ASE ISBN 978 0 86357 408 5;

- CLEAPSS® *Hazcards*, 2007 edition and later updates*;

- CLEAPSS® *Laboratory Handbook**;

- *Hazardous Chemicals*, A Manual for Science Education, 1997, SSERC Limited

  ISBN 0 9531776 0 2 (see www.sserc.org.uk/public/hazcd/whats_new.htm).

Where an e mployer has adopted these or other publications as the basis of their model risk assessments, an individual school or college then has to review them, to see if there is a need t o modify or adapt them in some way to suit the particular conditions of the establishment.

Such adaptations might include a r educed scale of working, deciding that the fume cupboard provision was inadequate or the skills of the candidates were insufficient to attempt particular activities safely. The significant findings of such risk assessment should then be r ecorded, for example on s chemes of work, published teachers guides, work sheets, etc. There is no s pecific legal requirement that detailed risk assessment forms should be c ompleted, although a few employers require this.

Where project work or individual investigations, sometimes linked to work-related activities, are included in specifications this may well lead to the use of novel procedures, chemicals or micro-organisms, which are not covered by the employer's model risk assessments. The employer should have given guidance on how to proceed in such cases. Often, for members, it will involve contacting CLEAPSS® (or, in Scotland, SSERC).

***These, and other CLEAPSS® publications, are on the CLEAPSS® Science Publications CD-ROM issued annually to members. Note that CLEAPSS® publications are only available to members. For more information about CLEAPSS® go to www.cleapss.org.uk. In Scotland, SSERC (www.sserc.org.uk) has a similar role to CLEAPSS® and there are some reciprocal arrangements.