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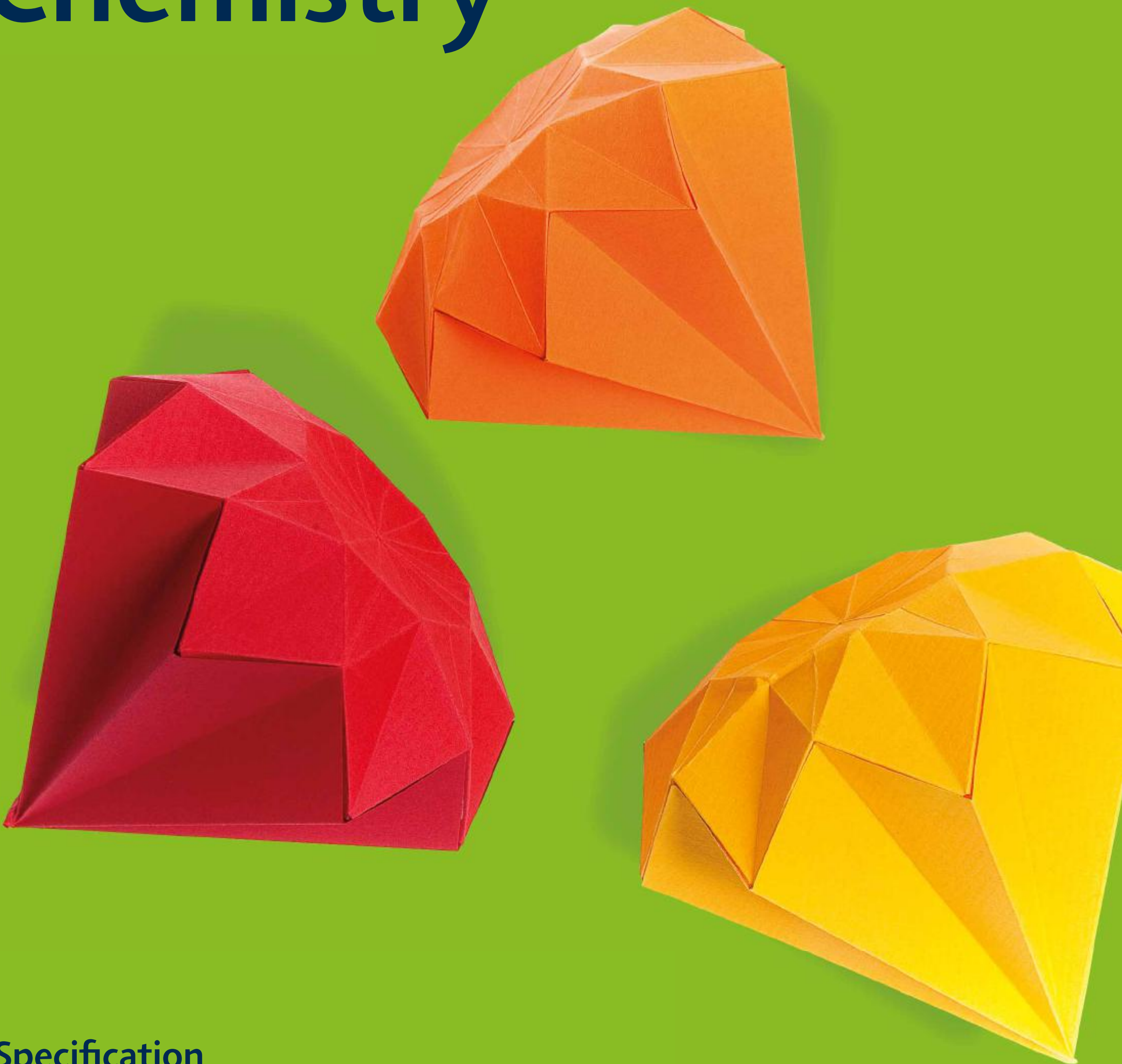

Specification

Pearson Edexcel Level 3 Advanced Subsidiary GCE in Chemistry (8CH0)

First teaching from September 2015

First certification from 2016

Issue 2

ALWAYS LEARNING

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Pearson Edexcel Level 3 Advanced Subsidiary GCE in Chemistry (8CH0)

Specification

First certification 2016

Issue 2

Edexcel, BTEC and LCCI qualifications

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This specification is Issue 2. Key changes are sidelined. We will inform centres of any changes to this issue. The latest issue can be found on our website.

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From Pearson's Expert Panel for World Class Qualifications

"The reform of the qualifications system in England is a profoundly important change to the education system. Teachers need to know that the new qualifications will assist them in helping their learners make progress in their lives.

When these changes were first proposed we were approached by Pearson to join an 'Expert Panel' that would advise them on the development of the new qualifications.

We were chosen, either because of our expertise in the UK education system, or because of our experience in reforming qualifications in other systems around the world as diverse as Singapore, Hong Kong, Australia and a number of countries across Europe.

We have guided Pearson through what we judge to be a rigorous qualification development process that has included:

- Extensive international comparability of subject content against the highest-performing jurisdictions in the world
- Benchmarking assessments against UK and overseas providers to ensure that they are at the right level of demand
- Establishing External Subject Advisory Groups, drawing on independent subject-specific expertise to challenge and validate our qualifications
- Subjecting the final qualifications to scrutiny against the DfE content and Ofqual accreditation criteria in advance of submission.

Importantly, we have worked to ensure that the content and learning is future oriented. The design has been guided by what is called an 'Efficacy Framework', meaning learner outcomes have been at the heart of this development throughout.

We understand that ultimately it is excellent teaching that is the key factor to a learner's success in education. As a result of our work as a panel we are confident that we have supported the development of qualifications that are outstanding for their coherence, thoroughness and attention to detail and can be regarded as representing world-class best practice."

Sir Michael Barber (Chair)
Chief Education Advisor, Pearson plc

Professor Sing Kong Lee
Director, National Institute of Education, Singapore

Bahram Bekhradnia
President, Higher Education Policy Institute

Professor Jonathan Osborne
Stanford University

Dame Sally Coates
Principal, Burlington Danes Academy

Professor Dr Ursula Renold
Federal Institute of Technology, Switzerland

Professor Robin Coningham
Pro-Vice Chancellor, University of Durham

Professor Bob Schwartz
Harvard Graduate School of Education

Dr Peter Hill
Former Chief Executive ACARA

Introduction

The Pearson Edexcel Level 3 Advanced Subsidiary GCE in Chemistry is designed for use in schools and colleges. It is part of a suite of GCE qualifications offered by Pearson.

Purpose of the specification

This specification sets out:

- the objectives of the qualification
- any other qualifications that a student must have completed before taking the qualification
- any prior knowledge and skills that the student is required to have before taking the qualification
- any other requirements that a student must have satisfied before they will be assessed or before the qualification will be awarded
- the knowledge and understanding that will be assessed as part of the qualification
- the method of assessment and any associated requirements relating to it
- the criteria against which a student’s level of attainment will be measured (such as assessment criteria).

Rationale

The Pearson Edexcel Level 3 Advanced Subsidiary GCE in Chemistry meets the following purposes, which fulfil those defined by the Office of Qualifications and Examinations Regulation (Ofqual) for GCE qualifications in their *GCE Qualification Level Conditions and Requirements* document, published in April 2014.

The purposes of this qualification are to:

- provide evidence of students' achievements in a robust and internationally comparable post-16 course of study that is a sub-set of Advanced GCE content
- enable students to broaden the range of subjects they study.

Qualification aims and objectives

The aims and objectives of the Pearson Edexcel Level 3 Advanced Subsidiary GCE in Chemistry are to enable students to develop:

- essential knowledge and understanding of different areas of the subject and how they relate to each other
- a deep appreciation of the skills, knowledge and understanding of scientific methods
- competence and confidence in a variety of practical, mathematical and problem-solving skills
- their interest in and enthusiasm for the subject, including developing an interest in further study and careers associated with the subject
- an understanding of how society makes decisions about scientific issues and how the sciences contribute to the success of the economy and society.

The context for the development of this qualification

All our qualifications are designed to meet our World Class Qualification Principles[1] and our ambition to put the student at the heart of everything we do.

We have developed and designed this qualification by:

- reviewing other curricula and qualifications to ensure that it is comparable with those taken in high-performing jurisdictions overseas
- consulting with key stakeholders on content and assessment, including subject associations, higher education academics, teachers and employers to ensure this qualification is suitable for a UK context
- reviewing the legacy qualification and building on its positive attributes.

This qualification has also been developed to meet criteria stipulated by Ofqual in their document *GCE Qualification Level Conditions and Requirements* and by the Department for Education (DfE) in their *GCE AS and A level regulatory requirements for biology, chemistry, physics and psychology* document, published in April 2014.

[1] Pearson's World Class Qualification principles ensure that our qualifications are:

- **demanding**, through internationally benchmarked standards, encouraging deep learning and measuring higher-order skills
- **rigorous**, through setting and maintaining standards over time, developing reliable and valid assessment tasks and processes, and generating confidence in end users of the knowledge, skills and competencies of certified students
- **inclusive**, through conceptualising learning as continuous, recognising that students develop at different rates and have different learning needs, and focusing on progression
- **empowering**, through promoting the development of transferable skills, see *Appendix 1*.

Contents

Qualification at a glance

The Pearson Edexcel Level 3 Advanced Subsidiary GCE in Chemistry consists of two externally examined papers.

Students are expected to carry out the eight core practical experiments that are identified in the content.

Students must complete both assessments in May/June in any single year.

Paper 1: Core Inorganic and Physical Chemistry	***Paper code: 8CH0/01**
• Externally assessed • Availability: May/June • First assessment: 2016	**50% of the total qualification**
Overview of content This paper will examine the following topics. • Topic 1: Atomic Structure and the Periodic Table • Topic 2: Bonding and Structure • Topic 3: Redox I • Topic 4: Inorganic Chemistry and the Periodic Table • Topic 5: Formulae, Equations and Amounts of Substance	
Overview of assessment • Assessment is 1 hour 30 minutes. • The paper consists of 80 marks. • The paper may include multiple-choice, short open, open-response, calculations and extended writing questions. • The paper will include questions that target mathematics at Level 2 or above (see *Appendix 6: Mathematical skills and exemplifications*). Overall, a minimum of 20% of the marks across both papers will be awarded for mathematics at Level 2 or above. • Some questions will assess conceptual and theoretical understanding of experimental methods (see *Appendix 5: Working scientifically*).	

*See *Appendix 3: Codes* for a description of this code and all other codes relevant to this qualification.

Paper 2: Core Organic and Physical Chemistry	*Paper code: 8CH0/02
• Externally assessed • Availability: May/June • First assessment: 2016	**50% of the total qualification**

Overview of content

This paper will examine the following topics:

- Topic 2: Bonding and Structure
- Topic 5: Formulae, Equations and Amounts of Substance
- Topic 6: Organic Chemistry I
- Topic 7: Modern Analytical Techniques I
- Topic 8: Energetics I
- Topic 9: Kinetics I
- Topic 10: Equilibrium I

Overview of assessment

- Assessment is 1 hour 30 minutes.
- The paper consists of 80 marks.
- The paper may include multiple-choice, short open, open-response, calculations and extended writing questions.
- The paper will include questions that target mathematics at Level 2 or above (see *Appendix 6: Mathematical skills and exemplifications*). Overall, a minimum of 20% of the marks across both papers will be awarded for mathematics at Level 2 or above.
- Some questions will assess conceptual and theoretical understanding of experimental methods (see *Appendix 5: Working scientifically*).

*See *Appendix 3: Codes* for a description of this code and all other codes relevant to this qualification.

Knowledge, skills and understanding

Content overview

Students will be expected to demonstrate and apply the knowledge, understanding and skills described in the content. In addition, they will be expected to analyse, interpret and evaluate a range of scientific information, ideas and evidence using their knowledge, understanding and skills.

To demonstrate their knowledge, students should be able to undertake a range of activities, including the ability to recall, describe and define, as appropriate. To demonstrate their understanding, students should be able to explain ideas and to use their knowledge to apply, analyse, interpret and evaluate, as appropriate.

Core practicals will be assessed through examination.

There are opportunities for students to develop mathematical skills throughout the content. They are required to apply these skills to relevant chemistry contexts. For further information see *Appendix 6: Mathematical skills and exemplifications*.

Practical skills

Practical work is central to any study of chemistry. For this reason, the specification includes eight core practical activities which form a thread linking theoretical knowledge and understanding to practical scenarios. In following this thread, students will build on practical skills learned at GCSE, becoming confident practical chemists, handling apparatus competently and safely. Using a variety of apparatus and techniques, they should be able to design and carry out both the core practical activities and their own investigations, collecting data which can be analysed and used to draw valid conclusions.

One important aspect of practical work is the ability to evaluate and manage potential risks. The variety of different practical techniques and scenarios in the core practical activities give students scope to consider risk management in different contexts.

Students should also consider the ethical issues presented by their work which, in the laboratory, might include consideration for using minimum quantities of resources, such as through microscale procedures; the safe disposal of waste materials, especially from organic reactions; and appropriate consideration for other people involved in their own work or who is working nearby.

Also central to the development of practical skills is the ability to communicate information and ideas through the use of appropriate terminology and ICT. Being able to communicate clearly the findings of practical work is arguably as important as the collection of accurate data.

In carrying out practical activities, students will be expected to use their knowledge and understanding to pose scientific questions which can be investigated through experimental activities. Such activities will enable students to collect data, analyse it for correlations and causal relationships, and to develop solutions to the questions posed.

Questions within written examination papers will aim to assess the knowledge and understanding that students gain while carrying out practical activities, within the context of the eight core practical activities, as well as in novel practical scenarios. The written papers will test the skills of students in planning practical work – both in familiar and unfamiliar applications – including risk management and the selection of apparatus, with reasons. As part of data handling, students will be expected to use significant figures appropriately, to process data and to plot graphs. In analysing outcomes and drawing valid conclusions, students should critically consider methods and data, including assessing measurement uncertainties and errors.

Examination papers will also provide the opportunity for students to evaluate the wider role of the scientific community in validating new knowledge and the ways in which society as a whole uses science to inform decision making. Within this, they could be asked to consider the implications and applications of chemistry in terms of associated benefits and risks. Students may also be asked to evaluate methodology, evidence and data and resolve conflicting evidence.

Success in questions that indirectly assess practical skills within written papers will come more naturally to those candidates who have a solid foundation of laboratory practice and who, having carried them out, have a thorough understanding of practical techniques. Therefore, where possible, teachers should consider adding additional experiments to the core practical activities. The eight core practicals will provide the basis from which some of the Paper 1 and Paper 2 examination questions will be drawn.

Topic 1: Atomic Structure and the Periodic Table

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible experiments include the use of hand-held spectroscopes to investigate spectra from flame tests.

Mathematical skills that could be developed in this topic include calculating a relative atomic mass from isotopic composition data, using simple probability to calculate the peak heights for the mass spectrum of chlorine molecules, using logarithms to compare successive ionisation energies for an element.

Within this topic, students can consider how models for the atom have developed over time, as new evidence has become available. They can also consider how data is used to investigate relationships, such as between the magnitude of ionisation energy and the structure of an atom.

Students should:
1. know the structure of an atom in terms of electrons, protons and neutrons
2. know the relative mass and relative charge of protons, neutrons and electrons
3. know what is meant by the terms 'atomic (proton) number' and 'mass number'
4. be able to determine the number of each type of sub-atomic particle in an atom, molecule or ion from the atomic (proton) number and mass number
5. understand the term 'isotopes'
6. be able to define the terms 'relative isotopic mass' and 'relative atomic mass', based on the ^{12}C scale
7. understand the terms 'relative molecular mass' and 'relative formula mass', including calculating these values from relative atomic masses *Definitions of these terms will not be expected.* *The term 'relative formula mass' should be used for compounds with giant structures.*
8. be able to analyse and interpret data from mass spectrometry to calculate relative atomic mass from relative abundance of isotopes and vice versa
9. be able to predict the mass spectra, including relative peak heights, for diatomic molecules, including chlorine
10. understand how mass spectrometry can be used to determine the relative molecular mass of a molecule *Limited to the m/z value for the molecular ion, M^+, giving the relative molecular mass of the molecule.*
11. be able to define the terms 'first ionisation energy' and 'successive ionisation energies'
12. understand how ionisation energies are influenced by the number of protons, the electron shielding and the electron sub-shell from which the electron is removed
13. understand reasons for the general increase in first ionisation energy across a period
14. understand reasons for the decrease in first ionisation energy down a group

Students should:
15. understand how ideas about electronic configuration developed from: i the fact that atomic emission spectra provide evidence for the existence of quantum shells ii the fact that successive ionisation energies provide evidence for the existence of quantum shells and the group to which the element belongs iii the fact that the first ionisation energy of successive elements provides evidence for electron sub-shells
16. know the number of electrons that can fill the first four quantum shells
17. know that an orbital is a region within an atom that can hold up to two electrons with opposite spins
18. know the shape of an *s*-orbital and a *p*-orbital
19. know the number of electrons that occupy *s*, *p* and *d*-subshells
20 know that electrons fill subshells singly, before pairing up, and that two electrons in the same orbital must have opposite spins
21. be able to predict the electronic configurations, using 1s notation and electrons-in-boxes notation, of: i atoms, given the atomic number, *Z*, up to *Z* = 36 ii ions, given the atomic number, *Z*, and the ionic charge, for *s* and *p* block ions only, up to *Z* = 36
22. know that elements can be classified as *s*, *p* and *d*-block elements
23. understand that electronic configuration determines the chemical properties of an element
24. understand periodicity in terms of a repeating pattern across different periods
25. understand reasons for the trends in the following properties of the elements from periods 2 and 3 of the Periodic Table: i the melting and boiling temperatures of the elements, based on given data, in terms of structure and bonding ii ionisation energy based on given data or recall of the plots of ionisation energy versus atomic number
26. be able to illustrate periodicity using data, including electronic configurations, atomic radii, melting and boiling temperatures and first ionisation energies

Topic 2: Bonding and Structure

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible experiments include investigating the migration of ions, for example in a U-tube of copper(II) chromate, seeing the effect of a charged rod on a flow of water.

Mathematical skills that could be developed in this topic include representing shapes of molecules with suitable sketches, plotting data to investigate trends in boiling temperatures of alkanes.

Within this topic, students can consider the strengths and weaknesses of the models used to describe different types of bonding. As part of their study of electron-pair repulsion theory, students can see how chemists can make generalisations and use them to make predictions.

Students should:
Topic 2A: Bonding
1. know that ionic bonding is the strong electrostatic attraction between oppositely charged ions
2. understand the effects that ionic radius and ionic charge have on the strength of ionic bonding
3. understand the formation of ions in terms of electron loss or gain
4. be able to draw electronic configuration diagrams of cations and anions using dot-and-cross diagrams
5. understand reasons for the trends in ionic radii down a group and for a set of isoelectronic ions, e.g. N^{3-} to Al^{3+}
6. understand that the physical properties of ionic compounds and the migration of ions provide evidence for the existence of ions
7. know that a covalent bond is the strong electrostatic attraction between two nuclei and the shared pair of electrons between them
8. be able to draw dot-and-cross diagrams to show electrons in covalent substances, including: i molecules with single, double and triple bonds ii species exhibiting dative covalent (co-ordinate) bonding, including Al_2Cl_6 and ammonium ion
9. understand the relationship between bond lengths and bond strengths for covalent bonds
10. understand that the shape of a simple molecule or ion is determined by the repulsion between the electron pairs that surround a central atom
11. understand reasons for the shapes of, and bond angles in, simple molecules and ions with up to six outer pairs of electrons (any combination of bonding pairs and lone pairs) *Examples should include $BeCl_2$, BCl_3, CH_4, NH_3, NH_4^+, H_2O, CO_2, PCl_5(g) and SF_6(g) and related molecules and ions; as well as simple organic molecules in this specification.*

Students should:
12. be able to predict the shapes of, and bond angles in, simple molecules and ions analogous to those specified above using electron-pair repulsion theory
13. know that electronegativity is the ability of an atom to attract the bonding electrons in a covalent bond
14. know that ionic and covalent bonding are the extremes of a continuum of bonding type and that electronegativity differences lead to bond polarity in bonds and molecules
15. understand that molecules with polar bonds may not be polar molecules and be able to predict whether or not a given molecule is likely to be polar
16. understand the nature of intermolecular forces resulting from the following interactions: i London forces (instantaneous dipole – induced dipole) ii permanent dipoles iii hydrogen bonds
17. understand the interactions in molecules, such as H_2O, liquid NH_3 and liquid HF, which give rise to hydrogen bonding
18. understand the following anomalous properties of water resulting from hydrogen bonding: i its relatively high melting temperature and boiling temperature ii the density of ice compared to that of water
19. be able to predict the presence of hydrogen bonding in molecules analogous to those mentioned above
20. understand, in terms of intermolecular forces, physical properties shown by materials, including: i the trends in boiling temperatures of alkanes with increasing chain length ii the effect of branching in the carbon chain on the boiling temperatures of alkanes iii the relatively low volatility (higher boiling temperatures) of alcohols compared to alkanes with a similar number of electrons iv the trends in boiling temperatures of the hydrogen halides, HF to HI
21. understand factors that influence the choice of solvents, including: i water, to dissolve some ionic compounds, in terms of the hydration of the ions ii water, to dissolve simple alcohols, in terms of hydrogen bonding iii water, as a poor solvent for compounds (to include polar molecules such as halogenoalkanes), in terms of inability to form hydrogen bonds iv non-aqueous solvents, for compounds that have similar intermolecular forces to those in the solvent
22. know that metallic bonding is the strong electrostatic attraction between metal ions and the delocalised electrons

Students should:
Topic 2B: Structure
23. know that giant lattices are present in: i ionic solids (giant ionic lattices) ii covalently bonded solids, such as diamond, graphite and silicon(IV) oxide (giant covalent lattices) iii solid metals (giant metallic lattices)
24. know that the structure of covalently bonded substances such as iodine, I_2, and ice, H_2O, is simple molecular
25. know the different structures formed by carbon atoms, including graphite, diamond and graphene
26. be able to predict the type of structure and bonding present in a substance from numerical data and/or other information
27. be able to predict the physical properties of a substance, including melting and boiling temperature, electrical conductivity and solubility in water, in terms of: i the types of particle present (atoms, molecules, ions, electrons) ii the structure of the substance iii the type of bonding and the presence of intermolecular forces, where relevant

Topic 3: Redox I

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible experiments include simple test tube reactions to investigate redox systems.

Mathematical skills that could be developed in this topic include using an algebraic method to work out the oxidation number of an element within a complex species, balancing equations for redox reactions by combining ionic half-equations.

Within this topic, students can consider how the concept of oxidation number provides a more considered route for the process of balancing chemical equations.

Students should:	
1.	know what is meant by the term 'oxidation number'
2.	be able to calculate the oxidation number of elements in compounds and ions *The use of oxidation numbers in peroxides and metal hydrides is expected.*
3.	understand oxidation and reduction in terms of electron transfer and changes in oxidation number, applied to reactions of *s*- and *p*-block elements
4.	understand oxidation and reduction in terms of electron loss or electron gain
5.	know that oxidising agents gain electrons
6.	know that reducing agents lose electrons
7.	understand that a disproportionation reaction involves an element in a single species being simultaneously oxidised and reduced
8.	know that oxidation number is a useful concept in terms of the classification of reactions as redox and as disproportionation
9.	be able to indicate the oxidation number of an element in a compound or ion, using a Roman numeral
10.	be able to write formulae given oxidation numbers
11.	understand that metals, in general, form positive ions by loss of electrons with an increase in oxidation number
12.	understand that non-metals, in general, form negative ions by gain of electrons with a decrease in oxidation number
13.	be able to write ionic half-equations and use them to construct full ionic equations

Topic 4: Inorganic Chemistry and the Periodic Table

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible experiments include reacting Group 2 elements with water, heating nitrates and carbonates of Group 1 and 2 elements, investigating flame colours of *s*-block elements, preparing iodine from seaweed, investigating displacement reactions in the halogens, reacting Group 1 halides with concentrated sulfuric acid.

Mathematical skills that could be developed in this topic include manipulating data on the solubility of hydroxides.

Within this topic, students can consider how data can be used to make predictions based on patterns and relationships, for example by predicting properties of Group 7 elements.

Students should:
Topic 4A: The elements of Groups 1 and 2
1. understand reasons for the trend in ionisation energy down Group 2
2. understand reasons for the trend in reactivity of the Group 2 elements down the group
3. know the reactions of the elements Mg to Ba in Group 2 with oxygen, chlorine and water
4. know the reactions of the oxides of Group 2 elements with water and dilute acid, and their hydroxides with dilute acid
5. know the trends in solubility of the hydroxides and sulfates of Group 2 elements
6. understand reasons for the trends in thermal stability of the nitrates and the carbonates of the elements in Groups 1 and 2 in terms of the size and charge of the cations involved
7. understand the formation of characteristic flame colours by Group 1 and 2 compounds in terms of electron transitions *Students will be expected to know the flame colours for Groups 1 and 2 compounds*.
8. understand experimental procedures to show: i patterns in thermal decomposition of Group 1 and 2 nitrates and carbonates ii flame colours in compounds of Group 1 and 2 elements

Students should:
Topic 4B: The elements of Group 7 (halogens)
9. understand reasons for the trends in melting and boiling temperatures, physical state at room temperature, and electronegativity for Group 7 elements
10. understand reasons for the trend in reactivity of Group 7 elements down the group
11. understand the trend in reactivity of Group 7 elements in terms of the redox reactions of Cl_2, Br_2 and I_2 with halide ions in aqueous solution, followed by the addition of an organic solvent
12. understand, in terms of changes in oxidation number, the following reactions of the halogens: i oxidation reactions with Group 1 and 2 metals ii the disproportionation reaction of chlorine with water and the use of chlorine in water treatment iii the disproportionation reaction of chlorine with cold, dilute aqueous sodium hydroxide to form bleach iv the disproportionation reaction of chlorine with hot alkali v reactions analogous to those specified above
13. understand the following reactions: i solid Group 1 halides with concentrated sulfuric acid, to illustrate the trend in reducing ability of the hydrogen halides ii precipitation reactions of the aqueous anions Cl^-, Br^- and I^- with aqueous silver nitrate solution, followed by aqueous ammonia solution iii hydrogen halides with ammonia and with water (to produce acids)
14. be able to make predictions about fluorine and astatine and their compounds, in terms of knowledge of trends in halogen chemistry
Topic 4C: Analysis of inorganic compounds
15. know reactions, including ionic equations where appropriate, for identifying: i carbonate ions, CO_3^{2-}, and hydrogencarbonate ions, HCO_3^-, using an aqueous acid to form carbon dioxide ii sulfate ions, SO_4^{2-}, using acidified barium chloride solution iii ammonium ions, NH_4^+, using sodium hydroxide solution and warming to form ammonia *Tests for halide ions and for the ions of Group 1 and 2 metals are also required, but are covered elsewhere in this Topic.*

Topic 5: Formulae, Equations and Amounts of Substance

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible experiments include determining a simple empirical formula such as MgO or CuO, determining the number of moles of water of crystallisation in a salt such as Epsom salts, performing a wide range of titrations involving different indicators, preparing salts.

Mathematical skills that could be developed in this topic include converting between units such as cm^3 and dm^3, using standard form with the Avogadro constant, rearranging formulae for calculating moles in solids and in solutions, calculating atom economy, dealing with percentage errors.

Within this topic, students first encounter core practicals and can consider ideas of measurement uncertainty, evaluating their results in terms of systematic and random errors. They can also consider how the concept of atom economy is useful to help chemists make decisions so that reactions can be made more efficient in terms of resources.

Students should:
1. know that the mole (mol) is the unit for amount of a substance
2. be able to use the Avogadro constant, *L*, (6.02×10^{23} mol^{-1}) in calculations
3. know that the molar mass of a substance is the mass per mole of the substance in g mol^{-1}
4. know what is meant by the terms 'empirical formula' and 'molecular formula'
5. be able to use experimental data to calculate i. empirical formulae ii. molecular formulae including the use of $pV = nRT$ for gases and volatile liquids *Calculations of empirical formula may involve composition by mass or percentage composition by mass data*.
6. be able to write balanced full and ionic equations, including state symbols, for chemical reactions
7. be able to calculate amounts of substances (in mol) in reactions involving mass, volume of gas, volume of solution and concentration *These calculations may involve reactants and/or products*.
8. be able to calculate reacting masses from chemical equations, and vice versa, using the concepts of amount of substance and molar mass
9. be able to calculate reacting volumes of gases from chemical equations, and vice versa, using the concepts of amount of substance
10. be able to calculate reacting volumes of gases from chemical equations, and vice versa, using the concepts of molar volume of gases
CORE PRACTICAL 1: Measure the molar volume of a gas
11. be able to calculate solution concentrations, in mol dm^{-3} and g dm^{-3}, including simple acid-base titrations using a range of acids, alkalis and indicators *The use of both phenolphthalein and methyl orange as indicators will be expected*.

Students should:
CORE PRACTICAL 2: Prepare a standard solution from a solid acid and use it to find the concentration of a solution of sodium hydroxide
CORE PRACTICAL 3: Find the concentration of a solution of hydrochloric acid
12. be able to: i calculate measurement uncertainties and measurement errors in experimental results ii comment on sources of error in experimental procedures
13. understand how to minimise the percentage error and percentage uncertainty in experiments involving measurements
14. be able to calculate percentage yields and percentage atom economies using chemical equations and experimental results $\text{Atom economy of a reaction} = \frac{\text{molar mass of the desired product}}{\text{sum of the molar masses of all products}} \times 100\%$
15. be able to relate ionic and full equations, with state symbols, to observations from simple test tube reactions, to include: i displacement reactions ii reactions of acids iii precipitation reactions
16. understand risks and hazards in practical procedures and suggest appropriate precautions where necessary

Topic 6: Organic Chemistry I

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible experiments include cracking of artificial crude oil, extracting limonene from orange peel, dehydrating an alcohol to an alkene, preparing a simple halogenoalkane such as 1-bromobutane, simple test tube reactions for different functional groups.

Mathematical skills that could be developed in this topic include calculating the yield of a reaction or an atom economy.

Within this topic, students can consider how the polymer industry provides useful solutions for many modern applications, but poses questions about sustainability of resources and the feasibility of recycling. They will also encounter practical organic chemistry, showing them how chemists work safely with potentially hazardous chemicals by managing risks.

Students should:
Topic 6A: Introduction to organic chemistry
1. know that a hydrocarbon is a compound of hydrogen and carbon only
2. be able to represent organic molecules using empirical formulae, molecular formulae, general formulae, structural formulae, displayed formulae and skeletal formulae
3. know what is meant by the terms 'homologous series' and 'functional group'
4. be able to name compounds relevant to this specification using the rules of International Union of Pure and Applied Chemistry (IUPAC) nomenclature *Students will be expected to know prefixes for compounds up to* C_{10}
5. be able to classify reactions as addition, elimination, substitution, oxidation, reduction, hydrolysis or polymerisation
6. understand the term 'structural isomerism' and determine the possible structural, displayed and skeletal formulae of an organic molecule, given its molecular formula
7. understand the term 'stereoisomerism', as illustrated by *E/Z* isomerism (including *cis-trans* isomerism where two of the substituent groups are the same)
Topic 6B: Alkanes
8. know the general formula for alkanes
9. know that alkanes and cycloalkanes are saturated hydrocarbons
10. understand that alkane fuels are obtained from the fractional distillation, cracking and reforming of crude oil *Reforming is described as the processing of straight-chain hydrocarbons into branched-chain alkanes and cyclic hydrocarbons for efficient combustion.*
11. know that pollutants, including carbon monoxide, oxides of nitrogen and sulfur, carbon particulates and unburned hydrocarbons, are formed during the combustion of alkane fuels

Students should:
12. understand the problems arising from pollutants from the combustion of fuels, limited to the toxicity of carbon monoxide and the acidity of oxides of nitrogen and sulfur
13. understand how the use of a catalytic converter solves some problems caused by pollutants
14. understand the use of alternative fuels, including biodiesel and alcohols derived from renewable sources such as plants, in terms of a comparison with non-renewable fossil fuels
15. know that a radical: i is a species with an unpaired electron and is represented in mechanisms by a single dot ii is formed by homolytic fission of a covalent bond and results in the formation of radicals
16. understand the reactions of alkanes with: i oxygen in air (combustion) ii halogens, in terms of the mechanism of radical substitution through initiation, propagation and termination steps *The use of curly half-arrows is not expected in this mechanism*.
17. understand the limitations of the use of radical substitution reactions in the synthesis of organic molecules, in terms of further substitution reactions and the formation of a mixture of products
Topic 6C: Alkenes
18. know the general formula for alkenes
19. know that alkenes and cycloalkenes are unsaturated hydrocarbons
20. understand the bonding in alkenes in terms of σ- and π- bonds
21. know what is meant by the term 'electrophile'
22. understand the addition reactions of alkenes with: i hydrogen, in the presence of a nickel catalyst, to form an alkane *Knowledge of the application of this reaction to the manufacture of margarine by catalytic hydrogenation of unsaturated vegetable oils is expected*. ii halogens to produce dihalogenoalkanes iii hydrogen halides to produce halogenoalkanes iv steam, in the presence of an acid catalyst, to produce alcohols v potassium manganate(VII), in acid conditions, to oxidise the double bond and produce a diol
23. understand that heterolytic bond fission of a covalent bond results in the formation of ions

Students should:
24. understand the mechanism of the electrophilic addition reactions between alkenes and: i halogens ii hydrogen halides, including addition to unsymmetrical alkenes iii other given binary compounds *Use of the curly arrow notation is expected – curly arrows should start from either a bond or from a lone pair of electrons*. *Knowledge of the relative stability of primary, secondary and tertiary carbocation intermediates is expected*.
25. know the qualitative test for a C=C double bond using bromine or bromine water
26. know that alkenes form polymers through addition polymerisation *Be able to identify the repeat unit of an addition polymer given the monomer, and vice versa.*
27. know that waste polymers can be separated into specific types of polymer for: i recycling ii incineration to release energy iii use as a feedstock for cracking
28. understand, in terms of the use of energy and resources over the life cycle of polymer products, that chemists can contribute to the more sustainable use of materials
29. understand how chemists limit the problems caused by polymer disposal by: i developing biodegradable polymers ii removing toxic waste gases caused by incineration of plastics
Topic 6D: Halogenoalkanes
30. know that halogenoalkanes can be classified as primary, secondary or tertiary
31. understand what is meant by the term ‘nucleophile’
32. understand the reactions of halogenoalkanes with: i aqueous potassium hydroxide to produce alcohols (where the hydroxide ion acts as a nucleophile) ii aqueous silver nitrate in ethanol (where water acts as a nucleophile) iii potassium cyanide to produce nitriles (where the cyanide ion acts as a nucleophile) *Students should know this as an example of increasing the length of the carbon chain.* iv ammonia to produce primary amines (where the ammonia molecule acts as a nucleophile) v ethanolic potassium hydroxide to produce alkenes (where the hydroxide ion acts as a base)

Students should:
33. understand that experimental observations and data can be used to compare the relative rates of hydrolysis of: i primary, secondary and tertiary halogenoalkanes ii chloro-, bromo-, and iodoalkanes using aqueous silver nitrate in ethanol
CORE PRACTICAL 4: Investigation of the rates of hydrolysis of some halogenoalkanes
34. know the trend in reactivity of primary, secondary and tertiary halogenoalkanes
35. understand, in terms of bond enthalpy, the trend in reactivity of chloro-, bromo-, and iodoalkanes
36. understand the mechanisms of the nucleophilic substitution reactions between primary halogenoalkanes and: i aqueous potassium hydroxide ii ammonia
Topic 6E: Alcohols
37. know that alcohols can be classified as primary, secondary or tertiary
38. understand the reactions of alcohols with: i oxygen in air (combustion) ii halogenating agents: • PCl_5 to produce chloroalkanes • 50% concentrated sulfuric acid and potassium bromide to produce bromoalkanes • red phosphorus and iodine to produce iodoalkanes iii potassium dichromate(VI) in dilute sulfuric acid to oxidise primary alcohols to aldehydes (including a test for the aldehyde using Benedict's/Fehling's solution) and carboxylic acids, and secondary alcohols to ketones *In equations, the oxidising agent can be represented as [O].* iv concentrated phosphoric acid to form alkenes by elimination *Descriptions of the mechanisms of these reactions are not expected.*
39. understand the following techniques used in the preparation and purification of a liquid organic compound: i heating under reflux ii extraction with a solvent in a separating funnel iii distillation iv drying with an anhydrous salt v boiling temperature determination
CORE PRACTICAL 5: The oxidation of ethanol
CORE PRACTICAL 6: Chlorination of 2-methylpropan-2-ol using concentrated hydrochloric acid

Topic 7: Modern Analytical Techniques I

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Hands-on practical work is limited in this topic, although many universities allow students to visit and learn about instrumentation first hand.

Mathematical skills that could be developed in this topic include analysing fragmentation patterns in mass spectra.

Within this topic, students can consider how different instrumental methods can provide evidence for analysis. They can see how accurate and sensitive methods of analysis can be applied to the study of chemical changes, but also to detect drugs such as in blood or urine testing in sport.

Students should:
Topic 7A: Mass spectrometry
1. be able to use data from a mass spectrometer to: i determine the relative molecular mass of an organic compound from the molecular ion peak ii suggest possible structures of a simple organic compound from the *m/z* of the molecular ion and fragmentation patterns
Topic 7B: Infrared (IR) spectroscopy
2. be able to use data from infrared spectra to deduce functional groups present in organic compounds and to predict infrared absorptions, given wavenumber data, due to familiar functional groups, including: i C–H stretching absorption in alkanes, alkenes and aldehydes ii C=C stretching absorption in alkenes iii O–H stretching absorption in alcohols iv C=O stretching absorption in aldehydes and ketones v C=O stretching absorption and the broad O-H stretching absorption in carboxylic acids vi N–H stretching absorption in amines
CORE PRACTICAL 7: Analysis of some inorganic and organic unknowns

Topic 8: Energetics I

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible experiments include a wide variety of calorimetry experiments involving displacement and neutralisation reactions, investigating the enthalpy of combustion of a homologous series of alcohols.

Mathematical skills that could be developed in this topic include plotting and extrapolating graphs of temperature rise against time for displacement reactions, calculating enthalpy changes in J and in kJ mol^{-1}, using algebra to solve Hess's law problems, calculating enthalpy changes using bond enthalpies.

Within this topic, students can consider how the use of Hess's Law can facilitate the study of energy changes in reactions which are not directly measureable. They can also consider the value of a general chemical concept, such as mean bond enthalpy, and why the use of a simplification such as this has some benefits, as well as some short-comings.

Students should:
1. know that standard conditions are 100 kPa and a specified temperature, usually 298 K
2. know that the enthalpy change is the heat energy change measured at constant pressure
3. be able to construct and interpret enthalpy level diagrams showing an enthalpy change, including appropriate signs for exothermic and endothermic reactions *Activation energy is not shown in enthalpy level diagrams but it is shown in reaction profile diagrams.*
4. be able to define standard enthalpy change of: i reaction ii formation iii combustion iv neutralisation
5. understand experiments to measure enthalpy changes in terms of: i processing results using the expression: energy transferred = mass x specific heat capacity × temperature change ($Q=mc\Delta T$) ii evaluating sources of error and assumptions made in the experiments *Students will need to consider experiments where*: ○ *substances are mixed in an insulated container and the temperature change is measured* ○ *enthalpy of combustion is measured, such as using a series of alcohols in a spirit burner* ○ *the enthalpy change cannot be measured directly*.
6. be able to calculate enthalpy changes in kJ mol^{-1} from given experimental results *Both a sign and units are expected in the final answer.*

Students should:
7. be able to construct enthalpy cycles using Hess's Law
8. be able to calculate enthalpy changes from data using Hess's Law
CORE PRACTICAL 8: To determine the enthalpy change of a reaction using Hess's Law
9. know what is meant by the terms 'bond enthalpy' and 'mean bond enthalpy'
10. be able to calculate an enthalpy change of reaction using mean bond enthalpies and explain the limitations of this method of calculation
11. be able to calculate mean bond enthalpies from enthalpy changes of reaction

Topic 9: Kinetics I

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible experiments include investigating a variety of factors that influence the rates of reaction between, for example, marble chips and hydrochloric acid, or sodium thiosulfate and hydrochloric acid, investigating catalysis using hydrogen peroxide.

Mathematical skills that could be developed in this topic include calculating rates from reaction time, plotting graphs and having an appreciation of the nature of the graph for a Maxwell-Boltzmann distribution.

Within this topic, students can consider how the use of models in chemistry is illustrated by the way in which the Maxwell-Boltzmann distribution and collision theory can account for the effects of changing variables on the rate of a chemical reaction.

Students should:
1. understand, in terms of collision theory, the effect of a change in concentration, temperature, pressure and surface area on the rate of a chemical reaction
2. understand that reactions only take place when collisions take place with sufficient energy, known as activation energy
3. be able to calculate the rate of a reaction from: i data showing the time taken for reaction ii the gradient of a suitable graph, by drawing a tangent, either for initial rate, or at a time, *t*
4. understand qualitatively, in terms of the Maxwell-Boltzmann distribution of molecular energies, how changes in temperature affect the rate of a reaction
5. understand the role of catalysts in providing alternative reaction routes of lower activation energy
6. be able to draw the reaction profiles for uncatalysed and catalysed reactions
7. be able to interpret the action of a catalyst in terms of a qualitative understanding of the Maxwell-Boltzmann distribution of molecular energies
8. understand the use of a solid (heterogeneous) catalyst for industrial reactions, in the gas phase, in terms of providing a surface for the reaction
9. understand the economic benefits of the use of catalysts in industrial reactions

Topic 10: Equilibrium I

In order to develop their practical skills, students should be encouraged to carry out a range of practical experiments related to this topic. Possible experiments include investigating equilibrium systems, such as iron(III) – thiocyanate, or the effect of temperature on the equilibrium between $[Co(H_2O)_6]^{2+}$ and $[CoCl_4]^{2-}$

Mathematical skills that could be developed in this topic include deriving an algebraic expression for the equilibrium constant.

Within this topic, students can consider how an appreciation of equilibrium processes, coupled with kinetics, can lead chemists to redevelop manufacturing processes to make them more efficient.

Students should:
1. know that many reactions are readily reversible and that they can reach a state of dynamic equilibrium in which: i the rate of the forward reaction is equal to the rate of the backward reaction ii the concentrations of reactants and products remain constant
2. be able to predict and justify the qualitative effect of a change in temperature, concentration or pressure on a homogeneous system in equilibrium
3. evaluate data to explain the necessity, for many industrial processes, to reach a compromise between the yield and the rate of reaction
4. be able to deduce an expression for K_c , for homogeneous and heterogeneous systems, in terms of equilibrium concentrations

Assessment

Assessment summary

Students must complete both assessments in May/June in any single year.

Paper 1: Core Inorganic and Physical Chemistry *Paper code: 8CH0/01	
• Questions draw on content from Topics 1–5. • Questions are broken down into a number of parts. • Availability: May/June • First assessment: 2016 • The assessment is 1 hour 30 minutes. • The assessment consists of 80 marks.	**50% of the total qualification**

Paper 2: Core Organic and Physical Chemistry *Paper code: 8CH0/02	
• Questions draw on content from Topic 2 and Topics 5–10. • Questions are broken down into a number of parts. • Availability: May/June • First assessment: 2016 • The assessment is 1 hour 30 minutes. • The assessment consists of 80 marks.	**50% of the total qualification**

The sample assessment materials can be found in the *Pearson Edexcel Level 3 Advanced Subsidiary GCE in Chemistry Sample Assessment Materials* document.

*See *Appendix 3: Codes* for a description of this code and all other codes relevant to this qualification.

Assessment Objectives and weightings

Students must:		% in GCE
AO1	Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures	35–37
AO2	Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: • in a theoretical context • in a practical context • when handling qualitative data • when handling quantitative data	41–43
AO3	Analyse, interpret and evaluate scientific information, ideas and evidence, including in relation to issues, to: • make judgements and reach conclusions • develop and refine practical design and procedures	20–23
	Total	**100%**

Breakdown of Assessment Objectives

Paper	AO1	AO2	AO3	Total for all Assessment Objectives
Paper 1: Core Inorganic and Physical Chemistry	17–19%	20–22%	10–12%	50%
Paper 2: Core Organic and Physical Chemistry	17–19%	20–22%	10–12%	50%
Total for this qualification	**35–37%**	**41–43%**	**20–23%**	**100%**

Entry and assessment information

Student entry

Details of how to enter students for the examinations for this qualification can be found in our *UK Information Manual*. A copy is made available to all examinations officers and is available on our website at: www.edexcel.com/iwantto/Pages/uk-information-manual.aspx

Forbidden combinations and discount code

Centres should be aware that students who enter for more than one GCE qualification with the same discount code will have only one of the grades they achieve counted for the purpose of the School and College Performance Tables – normally the better grade (please see *Appendix 3: Codes*).

Students should be advised that if they take two qualifications with the same discount code, colleges, universities and employers are very likely to take the view that they have achieved only one of the two GCEs. The same view may be taken if students take two GCE qualifications that have different discount codes but have significant overlap of content. Students or their advisers who have any doubts about their subject combinations should check with the institution to which they wish to progress before embarking on their programmes.

Access arrangements, reasonable adjustments and special consideration

Access arrangements

Access arrangements are agreed before an assessment. They allow students with special educational needs, disabilities or temporary injuries to:

- access the assessment
- show what they know and can do without changing the demands of the assessment.

The intention behind an access arrangement is to meet the particular needs of an individual student with a disability without affecting the integrity of the assessment. Access arrangements are the principal way in which awarding bodies comply with the duty under the Equality Act 2010 to make 'reasonable adjustments'.

Access arrangements should always be processed at the start of the course. Students will then know what is available and have the access arrangement(s) in place for assessment.

Reasonable adjustments

The Equality Act 2010 requires an awarding organisation to make reasonable adjustments where a person with a disability would be at a substantial disadvantage in undertaking an assessment. The awarding organisation is required to take reasonable steps to overcome that disadvantage.

A reasonable adjustment for a particular person may be unique to that individual and therefore might not be in the list of available access arrangements.

Whether an adjustment will be considered reasonable will depend on a number of factors, which will include:

- the needs of the student with the disability
- the effectiveness of the adjustment
- the cost of the adjustment; and
- the likely impact of the adjustment on the student with the disability and other students.

An adjustment will not be approved if it involves unreasonable costs to the awarding organisation, timeframes or affects the security or integrity of the assessment. This is because the adjustment is not 'reasonable'.

Special consideration

Special consideration is a post-examination adjustment to a student's mark or grade to reflect temporary injury, illness or other indisposition at the time of the examination/assessment, which has had, or is reasonably likely to have had, a material effect on a candidate's ability to take an assessment or demonstrate his or her level of attainment in an assessment.

Further information

Please see our website for further information about how to apply for access arrangements and special consideration.

For further information about access arrangements, reasonable adjustments and special consideration, please refer to the JCQ website: www.jcq.org.uk.

Malpractice

Candidate malpractice

Candidate malpractice refers to any act by a candidate that compromises or seeks to compromise the process of assessment or which undermines the integrity of the qualifications or the validity of results/certificates.

Candidate malpractice in examinations **must** be reported to Pearson using a *JCQ M1 Form* (available at www.jcq.org.uk/exams-office/malpractice). The form can be emailed to pqsmalpractice@pearson.com or posted to

Investigations Team, Pearson, 190 High Holborn, London, WC1V 7BH. Please provide as much information and supporting documentation as possible. Note that the final decision regarding appropriate sanctions lies with Pearson.

Failure to report malpractice constitutes staff or centre malpractice.

Staff/centre malpractice

Staff and centre malpractice includes both deliberate malpractice and maladministration of our qualifications. As with candidate malpractice, staff and centre malpractice is any act that compromises or seeks to compromise the process of assessment or which undermines the integrity of the qualifications or the validity of results/certificates.

All cases of suspected staff malpractice and maladministration **must** be reported immediately, before any investigation is undertaken by the centre, to Pearson on a *JCQ M2(a) Form* (available at www.jcq.org.uk/exams-office/malpractice). The form, supporting documentation and as much information as possible can be emailed to pqsmalpractice@pearson.com or posted to Investigations Team, Pearson, 190 High Holborn, London, WC1V 7BH. Note that the final decision regarding appropriate sanctions lies with Pearson.

Failure to report malpractice itself constitutes malpractice.

More-detailed guidance on malpractice can be found in the latest version of the document *JCQ General and Vocational Qualifications Suspected Malpractice in Examinations and Assessments,* available at www.jcq.org.uk/exams-office/malpractice.

Equality Act 2010 and Pearson's equality policy

Equality and fairness are central to our work. Our equality policy requires all students to have equal opportunity to access our qualifications and assessments, and our qualifications to be awarded in a way that is fair to every student.

We are committed to making sure that:

- students with a protected characteristic (as defined by the Equality Act 2010) are not, when they are undertaking one of our qualifications, disadvantaged in comparison to students who do not share that characteristic
- all students achieve the recognition they deserve for undertaking a qualification and that this achievement can be compared fairly to the achievement of their peers.

You can find details on how to make adjustments for students with protected characteristics in the policy document *Access Arrangements, Reasonable Adjustments and Special Considerations*, which is on our website, www.edexcel.com/Policies.

Synoptic assessment

Synoptic assessment requires students to work across different parts of a qualification and to show their accumulated knowledge and understanding of a topic or subject area.

Synoptic assessment enables students to show their ability to combine their skills, knowledge and understanding with breadth and depth of the subject. This can occur across topics within each assessment.

Awarding and reporting

This qualification will be graded, awarded and certificated to comply with the requirements of the current *Code of Practice* published by the Office of Qualifications and Examinations Regulation (Ofqual).

This qualification will be graded and certificated on a five-grade scale from A to E using the total subject mark. Individual papers are not graded.

The first certification opportunity for the Pearson Edexcel Level 3 Advanced Subsidiary GCE in Chemistry will be 2016.

Students whose level of achievement is below the minimum judged by Pearson to be of sufficient standard to be recorded on a certificate will receive an unclassified U result.

Language of assessment

Assessment of this qualification will be available in English. All student work must be in English.

Other information

Student recruitment

Pearson follows the JCQ policy concerning recruitment to our qualifications in that:

- they must be available to anyone who is capable of reaching the required standard
- they must be free from barriers that restrict access and progression
- equal opportunities exist for all students.

Prior learning and other requirements

There are no prior learning or other requirements for this qualification.

Students who would benefit most from studying this qualification are likely to have a Level 2 qualification such as a GCSE in Additional Science or Chemistry.

Progression

Students can progress from this Advanced Subsidiary GCE qualification to:

- an Advanced GCE in Chemistry
- a range of different, relevant academic or vocational higher education qualifications
- employment in a relevant sector
- further training.

Relationship between Advanced Subsidiary GCE and Advanced GCE

The content for the Advanced GCE in Chemistry includes all the content studied at Advanced Subsidiary GCE. The Advanced GCE in Chemistry builds on the knowledge, skills, and understanding achieved when studying the Advanced Subsidiary GCE in Chemistry.

Progression from Advanced Subsidiary GCE to Advanced GCE

Students who have achieved the Advanced Subsidiary GCE in Chemistry can progress to the Advanced GCE in Chemistry. They would have covered Topics 1–10 which are common to both qualifications but the additional Topics 11-19 will need to be covered. All the assessment for the Advanced GCE qualification must be taken at the end of the course.

Relationship between GCSE and Advanced Subsidiary GCE

Students cover Key Stage 4 fundamental core concepts in sciences at GCSE and continue to cover these concepts and additional subject material in the Advanced Subsidiary GCE at Key Stage 5.

Progression from GCSE to Advanced Subsidiary GCE

Students will draw on knowledge and understanding achieved in GCSE Additional Science or GCSE Chemistry to progress to an Advanced GCE in Chemistry qualification.

Appendices

Appendix 1: Transferable skills

The need for transferable skills

In recent years, higher education institutions and employers have consistently flagged the need for students to develop a range of transferable skills to enable them to respond with confidence to the demands of undergraduate study and the world of work.

The Organisation for Economic Co-operation and Development (OECD) defines skills, or competencies, as 'the bundle of knowledge, attributes and capacities that can be learned and that enable individuals to successfully and consistently perform an activity or task and can be built upon and extended through learning.'[1]

To support the design of our qualifications, the Pearson Research Team selected and evaluated seven global 21st-century skills frameworks. Following on from this process, we identified the National Research Council's (NRC) framework as the most evidence-based and robust skills framework. We adapted the framework slightly to include the Program for International Student Assessment (PISA) ICT Literacy and Collaborative Problem Solving (CPS) Skills.

The adapted National Research Council's framework of skills involves:[2]

Cognitive skills

- **Non-routine problem solving** – expert thinking, metacognition, creativity.
- **Systems thinking** – decision making and reasoning.
- **Critical thinking** – definitions of critical thinking are broad and usually involve general cognitive skills such as analysing, synthesising and reasoning skills.
- **ICT literacy** – access, manage, integrate, evaluate, construct and communicate[3].

Interpersonal skills

- **Communication** – active listening, oral communication, written communication, assertive communication and non-verbal communication.
- **Relationship-building skills** – teamwork, trust, intercultural sensitivity, service orientation, self-presentation, social influence, conflict resolution and negotiation.
- **Collaborative problem solving** – establishing and maintaining shared understanding, taking appropriate action, establishing and maintaining team organisation.

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[1] OECD (2012), Better Skills, Better Jobs, Better Lives (2012): http://skills.oecd.org/documents/OECDSkillsStrategyFINALENG.pdf

[2] Koenig, J. A. (2011) Assessing 21st Century Skills: Summary of a Workshop, National Research Council

[3] PISA (2011) The PISA Framework for Assessment of ICT Literacy, PISA

Intrapersonal skills

- **Adaptability** – ability and willingness to cope with the uncertain, handling work stress, adapting to different personalities, communication styles and cultures, and physical adaptability to various indoor and outdoor work environments.
- **Self-management and self-development** – ability to work remotely in virtual teams, work autonomously, be self-motivating and self-monitoring, willing and able to acquire new information and skills related to work.

Transferable skills enable young people to face the demands of further and higher education, as well as the demands of the workplace, and are important in the teaching and learning of this qualification. We will provide teaching and learning materials, developed with stakeholders, to support our qualifications.

Appendix 2: Level 3 Extended Project qualification

What is the Extended Project?

The Extended Project is a stand-alone qualification that can be taken alongside GCEs. It supports the development of 21st-century independent learning skills and helps to prepare students for their next step – whether that be university study or employment. The qualification:

- is recognised by universities for the skills it develops
- is worth half of an Advanced GCE qualification at grades to A*–E
- carries UCAS points for university entry.

The Extended Project encourages students to develop skills in the following areas: research, critical thinking, extended writing and project management. Students identify and agree a topic area of their choice (which may or may not be related to a GCE subject they are already studying), guided by their teacher.

Students can choose from one of four approaches to produce:

- a dissertation (for example an investigation based on predominately secondary research)
- an investigation/field study (for example a practical experiment)
- a performance (for example in music, drama or sport)
- an artefact (for example creating a sculpture in response to a client brief or solving an engineering problem).

The qualification is coursework based and students are assessed on the skills of managing, planning and evaluating their project. Students will research their topic, develop skills to review and evaluate the information, and then present the final outcome of their project.

Students: what they need to do

The Extended Project qualification requires students to:

- select a topic of interest for an in-depth study and negotiate the scope of the project with their teacher
- identify and draft an objective for their project (for example in the form of a question, hypothesis, challenge, outline of proposed performance, issue to be investigated or commission for a client) and provide a rationale for their choice
- produce a plan for how they will deliver their intended objective
- conduct research as required by the project brief, using appropriate techniques
- carry out the project using tools and techniques safely
- share the outcome of the project using appropriate communication methods, including a presentation.

Teachers: key information

- The Extended Project has 120 guided learning hours (GLH) consisting of:
  - a 40-GLH taught element that includes teaching the technical skills (for example research skills)
  - an 80-GLH guided element that includes mentoring students through the project work.
- Group work is acceptable, however it is important that each student provides evidence of their own contribution and produces their own report.
- 100% externally moderated
- Four Assessment Objectives: manage, use resources, develop and realise, review.
- Can be run over 1, 1½ or 2 years.
- Can be submitted in January or June.

What is the Extended Project for chemistry?

How to link the Extended Project with chemistry

The Extended Project creates the opportunity for students to develop transferable skills for progression to higher education and to the workplace through the exploration of either an area of personal interest or a topic of interest from the chemistry content.

For example, chemistry students could choose to carry out an investigation that would give them the opportunity to develop their skills in data collection, in the development and testing of hypotheses and in the application of mathematical models in data analysis.

Skills developed

Through the Extended Project students will develop skills in the following areas:

- independent research skills, including skills in primary research and the selection of appropriate methods for data collection
- extended reading and academic writing, including reading scientific literature and writing about trends or patterns in data sets
- planning/project management, including the refining of hypotheses to be tested in investigations
- data handling and evaluation, including the comparison of data from primary research with published data and exploration of the significance of results
- evaluation of arguments and processes, including arguments in favour of alternative interpretations of data and evaluation of experimental methodology
- critical thinking.

In the context of the Extended Project, critical thinking refers to the ability to identify and develop arguments for a point of view or hypothesis and to consider and respond to alternative arguments.

The Extended Project is an ideal vehicle to develop the skills identified in *Appendix 1*.

Using the Extended Project to support breadth and depth

There is no specified material that students are expected to study and, in the Extended Project, students are assessed on the quality of the work they produce and the skills they develop and demonstrate through completing this work. Students can use the Extended Project to demonstrate *extension* in one or more dimensions:

- ***deepening understanding***: where a student explores a topic in greater depth than in the specification content
- ***broadening skills***: the student learns a new skill. In a chemistry-based project, this might involve learning to assemble and manipulate an unfamiliar piece of apparatus or learning advanced data-handling techniques
- ***widening perspectives***: the student's project spans different subjects. This might involve discussing historical, philosophical or ethical aspects of a chemistry-based topic or making links with other subject areas such as economics.

Choosing topics and narrowing down to a question

A dissertation, typically around 6000 words in length, involves addressing a research question through a literature review and argumentative discussion while an investigation/field study involves data collection and analysis, leading to a written report of around 5000 words.

For example, consider a student with an interest in alternatives to conventional fuels who decided to carry out an investigation to compare the strengths and weaknesses of two different types of biodiesel. The investigation involved secondary research to establish the theoretical background to the project, to explore the uses and properties of different biodiesels and to consider what techniques can be used to gather data.

The student collected data using appropriately designed experiments. The student's own data were compared with published data, and the trends and patterns in data analysed, with consideration of the significance of the results obtained, and an attempt to interpret them in the light of the mathematical models that the student had learned about through research. The student drew conclusions about the relative merits of the two biodiesels, basing these conclusions on their own research together with analysis of published data. Finally, the student's project ended with a review of the effectiveness of the investigation and an oral presentation of the main findings and arguments considered.

Chemistry-based dissertation projects can cover a wide variety of topics, as these examples illustrate:

- Should legislation be used to enforce the principles of green chemistry?
- Could nanochemistry revolutionise medicine?

Examples of chemistry-based investigations include:

- Are calorific values in diet foods accurate?
- Can changing the method of synthesis significantly alter the material properties of a polymer?
- Is there a correlation between the chemical composition of a chilli pepper and its taste?
- Is the use of oil-dispersants an effective way of tackling oil spills?

There is also scope for chemistry-based artefact Extended Projects. For example, a student might set out to design, make and test an item of apparatus such as a spectrometer. Extended Projects involving a performance can also be chemistry based. For example, a social issue relating to chemistry could be explored through drama.

Appendix 3: Codes

Type of code	Use of code	Code number
Discount codes	Every qualification is assigned to a discount code indicating the subject area to which it belongs. This code may change. Please refer to our website (www.edexcel.com) for details of any changes.	For KS4 performance table: RD1 For 16–18 performance table: 1110
National Qualifications Framework (NQF) codes	Each qualification title is allocated an Ofqual National Qualifications Framework (NQF) code. The NQF code is known as a Qualification Number (QN). This is the code that features in the DfE Section 96 and on the LARA as being eligible for 16–18 and 19+ funding, and is to be used for all qualification funding purposes. The QN is the number that will appear on the student's final certification documentation.	The QN for the qualification in this publication is: 601/5647/8
Subject codes	The subject code is used by centres to enter students for a qualification. Centres will need to use the entry codes only when claiming students' qualifications.	Advanced Subsidiary GCE – 8CH0
Paper code	These codes are provided for reference purposes. Students do not need to be entered for individual papers	Paper 1: 8CH0/01 Paper 2: 8CH0/02

Appendix 4: Data Booklet

This appendix shows the data included in a Data Booklet that will be available on our website. Centres will be sent copies of the Data Booklet for the first examination series.

Centres can make additional fresh copies by printing the Data Booklet from our website. Candidates must use an unmarked copy of the Data Booklet in examinations.

Acknowledgement of source

The data used in the Data Booklet is derived from the *Nuffield Advanced Science, Revised Book of Data* (ISBN 058235448X), Nuffield Foundation.

Physical constants

Avogadro constant (*L*)	6.02×10^{23} mol^{-1}
Elementary charge (*e*)	1.60×10^{-19} C
Gas constant (*R*)	8.31 J mol^{-1} K^{-1}
Molar volume of ideal gas:	
at r.t.p.	24 dm^3 mol^{-1}
Specific heat capacity of water	4.18 J g^{-1} K^{-1}

1 dm^3 = 1 000 cm^3 = 0.001 m^3

Pauling electronegativities

Pauling electronegativity index

							H										He
							2·1										
Li	Be											B	C	N	O	F	Ne
1·0	1·5											2·0	2·5	3·0	3·5	4·0	
Na	Mg											Al	Si	P	S	Cl	Ar
0·9	1·2											1·5	1·9	2·1	2·5	3·0	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
0·8	1·0	1·3	1·5	1·6	1·6	1·5	1·8	1·8	1·8	1·9	1·6	1·6	2·0	2·0	2·4	2·8	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
0·8	1·0	1·2	1·3	1·6	2·1	1·9	2·2	2·2	2·2	1·9	1·6	1·7	1·9	1·9	2·1	2·5	
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
0·7	0·9	1·1	1·3	1·5	2·3	1·9	2·2	2·2	2·2	2·5	2·0	1·6	1·8	1·9	2·0	2·2	

Relation in electronegativity difference, ΔN_e and ionic character P/%

Electronegativity difference ΔN_e	0·1	0·3	0·5	0·7	1·0	1·3	1·5	1·7	2·0	2·5	3·0
Percentage ionic character P/%	0·5	2	6	12	22	34	43	51	63	79	89

Infrared spectroscopy

Correlation of infrared absorption wavenumbers with molecular structure

Group	Wavenumber range/cm^{-1}
C-H stretching vibrations	
Alkane	2962-2853
Alkene	3095-3010
Alkyne	3300
Arene	3030
Aldehyde	2900-2820 and 2775-2700
C-H bending variations	
Alkane	1485-1365
Arene 5 adjacent hydrogen atoms	750 and 700
4 adjacent hydrogen atoms	750
3 adjacent hydrogen atoms	780
2 adjacent hydrogen atoms	830
1 adjacent hydrogen atom	880
N-H stretching vibrations	
Amine	3500-3300
Amide	3500-3140
O-H stretching vibrations	
Alcohols and phenols	3750-3200
Carboxylic acids	3300-2500
C=C stretching vibrations	
Isolated alkene	1669-1645
Arene	1600, 1580, 1500, 1450
C=O stretching vibrations	
Aldehydes, saturated alkyl	1740-1720
Ketones, alkyl	1720-1700
Ketones, aryl	1700-1680
Carboxylic acids, alkyl	1725-1700
Carboxylic acids, aryl	1700-1680
Carboxylic acid anhydrides	1850-1800 and 1790-1740
Acyl halides, chlorides	1795
Acyl halides, bromides	1810
Esters, saturated	1750-1735
Amides	1700-1630
Triple bond stretching vibrations	
C≡N	2260-2215
C≡C	2260-2100

The Periodic Table of Elements

Key

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

1	2											3	4	5	6	7	0 (8)
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*	*(15)*	*(16)*	*(17)*	*(18)*
							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

* Lanthanide series	140 **Ce** cerium 58	141 **Pr** praseodymium 59	144 **Nd** neodymium 60	[147] **Pm** promethium 61	150 **Sm** samarium 62	152 **Eu** europium 63	157 **Gd** gadolinium 64	159 **Tb** terbium 65	163 **Dy** dysprosium 66	165 **Ho** holmium 67	167 **Er** erbium 68	169 **Tm** thulium 69	173 **Yb** ytterbium 70	175 **Lu** lutetium 71
* Actinide series	232 **Th** thorium 90	[231] **Pa** protactinium 91	238 **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 5: Working scientifically

Appendices 5 and *5a* are taken from the document *GCE AS and A level regulatory requirements for biology, chemistry, physics and psychology* published by the DfE in April 2014. Working scientifically is achieved through practical activities.

Specifications in biology, chemistry and physics must encourage the development of the skills, knowledge and understanding in science through teaching and learning opportunities for regular hands-on practical work.

Skills identified in *Appendix 5a* are assessed in the written examinations.

Appendix 5a: Practical skills identified for indirect assessment and developed through teaching and learning

Question papers will assess the following abilities:

a) Independent thinking

- solve problems set in practical contexts
- apply scientific knowledge to practical contexts

b) Use and application of scientific methods and practices

- comment on experimental design and evaluate scientific methods
- present data in appropriate ways
- evaluate results and draw conclusions with reference to measurement uncertainties and errors
- identify variables including those that must be controlled

c) Numeracy and the application of mathematical concepts in a practical context

- plot and interpret graphs
- process and analyse data using appropriate mathematical skills as exemplified in the mathematical appendix for each science
- consider margins of error, accuracy and precision of data

d) Instruments and equipment

- know and understand how to use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding included in the specification

Appendix 6: Mathematical skills and exemplifications

The information in this appendix has been taken directly from the document *GCE AS and A level regulatory requirements for biology, chemistry, physics and psychology* published by the Department for Education in April 2014.

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

The assessment of quantitative skills will include at least 10% Level 2 or above mathematical skills for biology and psychology, 20% for chemistry and 40% for physics. These skills will be applied in the context of the relevant science A Level.

All mathematical content must be assessed within the lifetime of the specification.

The following tables illustrate where these mathematical skills may be developed and could be assessed in each of the sciences. Those shown in **bold** type would be tested only in the full A Level course.

This list of examples is not exhaustive. These skills could be developed in other areas of specification content.

	Mathematical skills	Exemplification of mathematical skill in the context of A Level chemistry (assessment is not limited to the examples given below)
(i)	**B.0 – arithmetic and numerical computation**	
B.0.0	Recognise and make use of appropriate units in calculation	Candidates may be tested on their ability to: • convert between units, e.g. cm^3 to dm^3 as part of volumetric calculations • **give units for an equilibrium constant or a rate constant** • understand that different units are used in similar topic areas, so that conversions may be necessary, e.g. entropy in $J\ mol^{-1}\ K^{-1}$ and enthalpy changes in $kJ\ mol^{-1}$
B.0.1	Recognise and use expressions in decimal and ordinary form	Candidates may be tested on their ability to: • use an appropriate number of decimal places in calculations, e.g. for pH • carry out calculations using numbers in standard and ordinary form, e.g. use of Avogadro's number • understand standard form when applied to areas such as (but not limited to) K_w • convert between numbers in standard and ordinary form • understand that significant figures need retaining when making conversions between standard and ordinary form, e.g. 0.0050 mol dm^{-3} is equivalent to 5.0×10^{-3} mol dm^{-3}
B.0.2	Use ratios, fractions and percentages	Candidates may be tested on their ability to: • calculate percentage yields • calculate the atom economy of a reaction • construct and/or balance equations using ratios

	Mathematical skills	Exemplification of mathematical skill in the context of A Level chemistry (assessment is not limited to the examples given below)
B.0.3	Make estimates of results of calculations (without using a calculator).	Candidates may be tested on their ability to: • **evaluate the effect of changing experimental parameters on measurable values, e.g. how the value of K_c would change with temperature given different specified conditions**
B.0.4	Use calculators to find and use power, **exponential and logarithmic functions**	Candidates may be tested on their ability to: • carry out calculations using the Avogadro constant • **carry out pH and pK_a calculations** • **make appropriate mathematical approximations in buffer calculations**
(ii)	**B.1 – handling data**	
B.1.1	Use an appropriate number of significant figures	Candidates may be tested on their ability to: • report calculations to an appropriate number of significant figures given raw data quoted to varying numbers of significant figures • understand that calculated results can only be reported to the limits of the least accurate measurement
B.1.2	Find arithmetic means	Candidates may be tested on their ability to: • calculate weighted means, e.g. calculation of an atomic mass based on supplied isotopic abundances • select appropriate titration data (i.e. identification of outliers) in order to calculate mean titres
B.1.3	Identify uncertainties in measurements and use simple techniques to determine uncertainty when data are combined	Candidates may be tested on their ability to: • determine uncertainty when two burette readings are used to calculate a titre value

	Mathematical skills	Exemplification of mathematical skill in the context of A Level chemistry (assessment is not limited to the examples given below)
(iii)	**B.2 – algebra**	
B.2.1	Understand and use the symbols: =, <, <<, >>, >, ∝, ~, equilibrium sign	No exemplification required.
B.2.2	Change the subject of an equation	Candidates may be tested on their ability to: • carry out structured and unstructured mole calculations, **e.g. calculate a rate constant *k* from a rate equation**
B.2.3	Substitute numerical values into algebraic equations using appropriate units for physical quantities	Candidates may be tested on their ability to: • carry out structured and unstructured mole calculations • **carry out rate calculations** • **calculate the value of an equilibrium constant K_c**
B.2.4	Solve algebraic equations	Candidates may be tested on their ability to: • carry out Hess's law calculations • **calculate a rate constant k from a rate equation**
B.2.5	**Use logarithms in relation to quantities that range over several orders of magnitude**	Candidates may be tested on their ability to: • **carry out pH and pK_a calculations**
(iv)	**B.3 – graphs**	
B.3.1	Translate information between graphical, numerical and algebraic forms	Candidates may be tested on their ability to: • interpret and analyse spectra • **determine the order of a reaction from a graph** • **derive rate expression from a graph**
B.3.2	Plot two variables from experimental or other data	Candidates may be tested on their ability to: • plot concentration-time graphs from collected or supplied data and draw an appropriate best-fit curve

	Mathematical skills	Exemplification of mathematical skill in the context of A Level chemistry (assessment is not limited to the examples given below)
B.3.3	**Determine the slope and intercept of a linear graph**	Candidates may be tested on their ability to: • **calculate the rate constant of a zero-order reaction by determination of the gradient of a concentration–time graph**
B.3.4	**Calculate rate of change from a graph showing a linear relationship**	Candidates may be tested on their ability to: • **calculate the rate constant of a zero-order reaction by determination of the gradient of a concentration–time graph**
B.3.5	**Draw and use the slope of a tangent to a curve as a measure of rate of change**	Candidates may be tested on their ability to: • **determine the order of a reaction using the initial rates method**
(v)	**B.4 – geometry and trigonometry**	
B.4.1	Appreciate angles and shapes in regular 2D and 3D structures.	Candidates may be tested on their ability to: • predict/identify shapes of and bond angles in molecules with and without a lone pair(s), for example NH_3, CH_4, H_2O etc
B.4.2	Visualise and represent 2D and 3D forms including two-dimensional representations of 3D objects	Candidates may be tested on their ability to: • draw different forms of isomers • **identify chiral centres from a 2D or 3D representation**
B.4.3	Understand the symmetry of 2D and 3D shapes	Candidates may be tested on their ability to: • describe the types of stereoisomerism shown by molecules/complexes • **identify chiral centres from a 2D or 3D representation**

Appendix 7: Command words used in examination papers

The following table lists the command words used in the external assessments.

Command word	Definition
Add/Label	Requires the addition or labelling to a stimulus material given in the question, for example labelling a diagram or adding units to a table.
Assess	Give careful consideration to all the factors or events that apply and identify which are the most important or relevant. Make a judgement on the importance of something, and come to a conclusion where needed.
Calculate	Obtain a numerical answer, showing relevant working. If the answer has a unit, this must be included.
Comment on	Requires the synthesis of a number of variables from data/information to form a judgement.
Compare and contrast	Looking for the similarities **and** differences of two (or more) things. Should not require the drawing of a conclusion. Answer must relate to both (or all) things mentioned in the question. The answer must include at least one similarity and one difference.
Complete	Requires the completion of a table/diagram.
Criticise	Inspect a set of data, an experimental plan or a scientific statement and consider the elements. Look at the merits and faults of the information presented and back judgements made by giving evidence.
Deduce	Draw/reach conclusion(s) from the information provided.
Describe	To give an account of something. Statements in the response need to be developed as they are often linked but do not need to include a justification or reason.
Determine	The answer must have an element which is quantitative from the stimulus provided, or must show how the answer can be reached quantitatively. To gain maximum marks there must be a quantitative element to the answer.
Devise	Plan or invent a procedure from existing principles/ideas
Discuss	• Identify the issue/situation/problem/argument that is being assessed within the question. • Explore all aspects of an issue/situation/problem/argument. • Investigate the issue/situation etc by reasoning or argument.

Command word	Definition
Draw	Produce a diagram either using a ruler or using freehand.
Evaluate	Review information then bring it together to form a conclusion, drawing on evidence including strengths, weaknesses, alternative actions, relevant data or information. Come to a supported judgement of a subject's qualities and relation to its context.
Explain	An explanation requires a justification/exemplification of a point. The answer must contain some element of reasoning/justification, this can include mathematical explanations.
Give/State/Name	All of these command words are really synonyms. They generally all require recall of one or more pieces of information.
Give a reason/reasons	When a statement has been made and the requirement is only to give the reasons why.
Identify	Usually requires some key information to be selected from a given stimulus/resource.
Justify	Give evidence to prove (either the statement given in the question or an earlier answer)
Plot	Produce a graph by marking points accurately on a grid from data that is provided and then drawing a line of best fit through these points. A suitable scale and appropriately labelled axes must be included if these are not provided in the question.
Predict	Give an expected result.
Show that	Verify the statement given in the question.
Sketch	Produce a freehand drawing. For a graph this would need a line and labelled axis with important features indicated, the axis are not scaled.
State what is meant by	When the meaning of a term is expected but there are different ways of how these can be described.
Write	When the questions ask for an equation.

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