Qualifications and Curriculum Authority

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

GCE AS and A level subject criteria for science subjects

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Contents

1. Introduction

1.1 Advanced Subsidiary (AS) and Advanced (A) level subject criteria set out the knowledge, understanding, skills and assessment objectives common to all AS and A level specifications in a given subject. They provide the framework within which the awarding body creates the detail of the specification.

1.2 Subject criteria are intended to:

- help ensure consistent and comparable standards in the same subject across the awarding bodies
- define the relationship between the AS and A level specifications, with the AS as a subset of the A level
- ensure that the rigour of A level is maintained
- help higher education institutions and employers know what has been studied and assessed.

1.3 Any specification which contains significant elements of any subjects included must be consistent with the relevant parts of these subject criteria.

2. Aims

2.1 AS and A level specifications in a science subject should encourage students to:

a) develop their interest in, and enthusiasm for the subject, including developing an interest in further study and careers in the subject

b) appreciate how society makes decisions about scientific issues and how the sciences contribute to the success of the economy and society

c) develop and demonstrate a deeper appreciation of the skills, knowledge and understanding of *How science works*

b) develop essential knowledge and understanding of different areas of the subject and how they relate to each other.

3. Specification content

3.1 AS and A level science specifications must build on the skills, knowledge and understanding set out in the *GCSE criteria for science*.

3.2 The skills, knowledge and understanding set out in the appendices for each science subject must comprise for AS approximately 60 per cent of the specification. The skills, knowledge and understanding for AS and A2 combined must comprise approximately 60 per cent of an A level specification.

3.3 The remainder of both AS and A level specifications allows both for:

- further consideration of applications and implications of science and the development of scientific ideas
- the introduction of different areas of study.

3.4 AS and A level specifications must include a range of contemporary and other contexts.

3.5 AS and A level specifications must require students to cover the areas of the subject as illustrated in the relevant appendix below with the content at A2, shown in bold, organised so that it builds on and extends AS.

3.6 The skills, knowledge and understanding of *How science works* must include the requirements set out below, and must be integrated into the mandatory content indicated in the relevant annex and any content added by the awarding body.

- Use theories, models and ideas to develop and modify scientific explanations
- Use knowledge and understanding to pose scientific questions, define scientific problems, present scientific arguments and scientific ideas
- Use appropriate methodology, including ICT, to answer scientific questions and solve scientific problems
- Carry out experimental and investigative activities, including appropriate risk management, in a range of contexts
- Analyse and interpret data to provide evidence, recognising correlations and causal relationships
- Evaluate methodology, evidence and data, and resolve conflicting evidence
- Appreciate the tentative nature of scientific knowledge
- Communicate information and ideas in appropriate ways using appropriate terminology
- Consider applications and implications of science and appreciate their associated benefits and risks
- Consider ethical issues in the treatment of humans, other organisms and the environment
- Appreciate the role of the scientific community in validating new knowledge and ensuring integrity
- Appreciate the ways in which society uses science to inform decision-making

3.7 Development of the skills, knowledge and understanding of the science subjects must include the mathematical requirements set out in appendix 8.

4. Key skills

4.1 AS and A level specifications in computing should provide opportunities for developing and generating evidence for assessing relevant key skills from the list below. Where appropriate, these opportunities should be directly cross-referenced, at specified level(s) to the key skills standards which may be found on the QCA website (www.qca.org.uk).

- Application of number
- Communication
- Improving own learning and performance
- Information and communication technology
- Problem solving
- Working with others

5. Assessment objectives

5.1 These assessment objectives are the same for AS and A level. They apply to the whole specification.

5.2 Specifications must require, in all assessment units, that candidates demonstrate these assessment objectives in the context of the skills, knowledge and understanding prescribed, including using extended prose.

5.3 Each assessment unit must address one, or more, aspects of each of the assessment objectives

5.4 In the context of these assessment objectives, the following definitions apply:

- Knowledge: includes facts, specialist vocabulary, principles, concepts, theories, models, practical techniques, studies and methods.
- Issues: include ethical, social, economic, environmental, cultural, political and technological.
- Processes: include collecting evidence, explaining, theorising, modelling, validating, interpreting, planning to test an idea, peer reviewing.

5.5 **AO1: Knowledge and understanding of science and of *How science works***

Candidates should be able to:

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

5.6 **AO2: Application of knowledge and understanding of science and of *How science works***

Candidates should be able to:

a) analyse and evaluate scientific knowledge and processes
b) apply scientific knowledge and processes to unfamiliar situations including those related to issues
c) assess the validity, reliability and credibility of scientific information

5.7.1 **AO3: *How science works* – Biology, Chemistry, Physics, Geology, Electronics and Environmental Science**

Candidates should be able to:

a) demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods.

b) make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy.

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

5.7.2 **AO3: *How science works* – Psychology**

Due to the potential age of A level candidates and the possible nature of investigative activities in psychology, candidates will not be expected to demonstrate the skills of investigation through internal assessment. Candidates should therefore be able to:

a) describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods.

b) know how to make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy, through using primary and secondary sources.

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

It is expected, however, that candidates should still carry out investigative activities, appropriate for the study of psychology at this level.

5.8 The assessment objectives are to be weighted in all specifications as indicated. These apply to the whole specification.

Assessment objectives		**Weighting**		
		AS level	**A2 level**	**A level**
AO1	Knowledge and understanding	30–40%	20–30%	25–35%
AO2	Application of knowledge and understanding	30–40%	40–50%	35–45%
AO3	How science works	20–40%	20–40%	20–40%

6. Scheme of assessment

6.1 Number of assessment units

1. All of the GCE A level in science subjects will contain 6 assessment units, with the exception of the GCE A level in psychology which will contain 4 assessment units.
2. All units in psychology will be externally assessed.
3. In the 6 unit GCE A level science subjects, one of the assessment units at AS and one of the assessment units at A2 must be internally assessed. Each of the internally assessed units at AS and A2 must include the assessment of practical skills.
4. In the 6 unit GCE A level science subjects, the minimum weighting of each internally assessed unit must be between 20 and 30% for each of AS and A2.

6.2 Internal assessment

Where internal assessment is included, specifications must make clear how reliability and fairness are secured, by setting out requirements that ensure the robustness of each stage of the internal assessment, ie:

- the specific skills to be assessed
- setting of tasks
- extent of supervision in carrying out of tasks
- conditions under which assessment takes place
- marking of the assessment and internal standardising procedures
- any moderation process.

6.3 Synoptic assessment

There is a requirement to formally assess synopticity at A2. The definition of synoptic assessment in the context of science is:

Synoptic assessment requires candidates to make and use connections within and between different areas of the subject at AS and A2, for example, by:

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

6.4 Quality of written communication

AS and A level specifications will be required to assess the candidates' quality of written communication in accordance with the guidance document produced by QCA.

Appendix 1: Biology – Knowledge and understanding

This appendix must be read in conjunction with section 3 of the science criteria. The AS knowledge and understanding set out in this appendix should comprise approximately 60 per cent of the AS specification. The AS and A2 knowledge and understanding combined should comprise approximately 60 per cent of an A level specification. The A2 content is shown in bold.

1.1 Biology specifications must ensure that there is an appropriate balance between plant biology, animal biology and microbiology and include an appreciation of the relevance of sustainability to all aspects of scientific developments.

1.2 Living organisms, including plants, animals and micro-organisms, interact with each other and with the non-living world. The living world can be studied at population, organism, cell and molecular levels. There are fundamental similarities as well as differences between plants, animals and micro-organisms.

	AS	**A2**
Population	Biodiversity	**Ecosystems**
Organism	Exchange and transport	**Control systems**
Cell	Cells	**Cellular control**
Molecular	Biological molecules	**Energy for biological processes**

1.3 Biodiversity

a) The variety of life, both past and present, is extensive but the biochemical basis of life is similar for all living things.

b) Biodiversity refers to the variety and complexity of life and may be considered at different levels.

c) Biodiversity can be measured, for example within a habitat or at the genetic level.

d) Classification is a means of organising the variety of life based on relationships between organisms and is built around the concept of species.

e) Originally classification systems were based on observable features but more recent approaches draw on a wider range of evidence to clarify relationships between organisms.

f) Adaptations of organisms to their environments can be behavioural or physiological as well as anatomical.

g) Adaptation and selection are major components of evolution and make a significant contribution to the diversity of living organisms.

1.4 Exchange and transport

a) Organisms need to exchange substances selectively with their environment and this takes place at exchange surfaces.

b) Factors such as size or metabolic rate affect the requirements of organisms and this gives rise to adaptations such as specialised exchange surfaces and mass transport systems.

c) Substances are exchanged by passive or active transport across exchange surfaces.

d) The structure of the plasma membrane enables control of the passage of substances in and out of cells.

1.5 Cells

a) Organisms usually consist of one or more cells.

b) Prokaryotic and eukaryotic cells can be distinguished on the basis of their structure and ultrastructure.

c) In complex multicellular organisms cells are organised into tissues, tissues into organs and organs into systems.

d) During the cell cycle genetic information is copied and passed to daughter cells.

e) Daughter cells formed during mitosis have identical copies of genes while cells produced as a result of meiosis are not genetically identical.

1.6 Biological molecules

a) Biological molecules are often polymers and are based on a small number of chemical elements.

b) In living organisms nucleic acids (DNA and RNA), carbohydrates, proteins, lipids, inorganic ions and water all have important roles and functions related to their properties.

c) Enzymes are proteins with a mechanism of action and other properties determined by their tertiary structure.

d) Enzymes catalyse a wide range of intracellular reactions as well as extracellular ones.

1.7 Ecosystems

a) Ecosystems range in size from the very large to the very small.

b) Energy flows through ecosystems and the efficiency of transfer through different trophic levels can be measured.

c) Microorganisms play a key role in recycling chemical elements.

d) Ecosystems are dynamic systems, usually moving from colonisation to climax communities in a process known as succession.

e) The dynamic equilibrium of populations is affected by a range of factors

f) Humans are part of the ecological balance and their activities affect it both directly and indirectly.

g) Sustainability of resources depends on effective management of the conflict between human needs and conservation.

1.8 Control systems

a) Homeostasis is the maintenance of a constant internal environment.

b) Negative feedback helps maintain an optimal internal state in the context of a dynamic equilibrium. Positive feedback also occurs.

c) Stimuli, both internal and external, are detected leading to responses.

d) Co-ordination may be chemical or electrical in nature.

1.9 Cellular control

a) The sequence of bases in the DNA molecule, known as the genetic code, determines the structure of proteins, including enzymes.

b) Enzymes catalyse the reactions that determine structures and functions from cellular to whole-organism level.

c) Transfer of genetic information from one generation to the next can ensure continuity of species or lead to variation within a species and eventual formation of new species.

d) Reproductive isolation can lead to accumulation of different genetic information in populations potentially leading to formation of new species

e) Sequencing projects have read the genomes of organisms ranging from microbes and plants to humans. This allows the sequences of the proteins that derive from the genetic code to be predicted.

f) Gene technologies allow study and alteration of gene function in order to better understand organism function and to design new industrial and medical processes

1.10 Energy for biological processes

a) ATP provides the immediate source of energy for biological processes.

b) In cellular respiration, glycolysis takes place in the cytoplasm and the remaining steps in the mitochondria.

c) ATP synthesis is associated with the electron transfer chain in the membranes of mitochondria and chloroplasts.

d) In photosynthesis energy is transferred to ATP in the light-dependent stage and the ATP is utilised during synthesis in the light-independent stage.

Appendix 2: Chemistry – Knowledge and understanding

This appendix must be read in conjunction with section 3 of the science criteria. The AS knowledge and understanding set out in this appendix should comprise approximately 60 per cent of the AS specification. The AS and A2 knowledge and understanding combined should comprise approximately 60 per cent of an A level specification. The A2 content is shown in bold.

2.1 Chemistry specifications must ensure that there is an appreciation of the relevance of sustainability to all aspects of scientific developments.

2.2 Formulae, equations and amounts of substance

a) Empirical and molecular formulae.
b) Balanced chemical equations (full and ionic).
c) The Avogadro constant and the amount of substance (mole).
d) Relative atomic mass and relative isotopic mass.
e) Calculation of reacting masses, mole concentrations, volumes of gases, % yields and atom economies.
f) Simple acid–base titrations.
g) Non-structured titration calculations, based solely on experimental results.

2.3 Atomic structure

a) Structure and electronic configuration of atoms (up to Z = 36) in terms of main energy levels and *s, p* and *d* orbitals.
b) Ions and isotopes. Use of mass spectrometry in determining relative atomic mass and relative abundance of isotopes.

2.4 Bonding and structure

a) Interpretation of ionic and covalent bonding in terms of electron arrangements. Examples of simple covalent, giant covalent, ionic and metallic structures.
b) Permanent and induced dipole–dipole interactions between molecules, including hydrogen bonding. Electronegativity and its application to bond type. Interpretation of the physical properties of materials in terms of structure and bonding.
c) Shapes of simple molecules and ions with up to six outer pairs of electrons (any combination of bonding pairs and lone pairs). Interpretation in terms of electron pair repulsion theory.

2.5 Energetics

a) Enthalpy changes, including standard enthalpy changes of reaction, formation and combustion. Average bond enthalpies.
b) Use of Hess's law to calculate enthalpy changes.
c) Use of energetics, including entropy, to predict the feasibility of reactions.

2.6 Kinetics

a) A qualitative understanding of collision theory. Activation energy and its relationship to the qualitative effect of temperature changes on rate of reaction.
b) The role of catalysts in providing alternative routes of lower activation energy.

c) Determination and use of rate equations of the form: *Rate = k[A]^m[B]^n*, where *m* and *n* are integers. Using orders of reactions where appropriate, which may give information about a rate-determining/limiting step.

2.7 Equilibria

a) The dynamic nature of equilibria. For homogeneous reactions, the qualitative effects of temperature, pressure and concentration changes on the position of equilibrium.

b) Equilibrium constants, K_c . Calculation of K_c and reacting quantities.

c) The effect of temperature changes on K_c.

d) The Bronsted–Lowry theory of acid–base reactions. The ionic product of water, K_w. pH and its calculation for strong acids and strong bases.

e) Dissociation constants of weak acids, K_a. Calculation of pH for weak acids. Buffer solutions and their applications.

2.8 Redox

a) Oxidation states and their calculation.

b) Oxidation and reduction as electron transfer, applied to reactions of *s, p* **and *d* block elements.**

c) Electrode potentials and their applications.

2.9 Inorganic chemistry and the periodic table

a) The organisation of elements according to their proton number and electronic structures. Classification of elements into *s, p* and *d* blocks.

b) The characteristic reactions of the elements and compounds of a metallic group and a non-metallic group. Trends in properties of elements and compounds within these groups.

c) Trends in properties of elements across a period including:

i. melting point

ii. ionisation energy.

d) The transition metals as *d* block elements forming one or more stable ions which have incompletely filled *d* orbitals. At least two transition metals, chosen from titanium to copper, to illustrate:

i. the existence of more than one oxidation state for each element in its compounds

ii. the formation of coloured ions in solution and simple precipitation reactions of these

iii. reactions with ligands to form complexes and reactions involving ligand substitution

iv. the catalytic behaviour of the elements and their compounds.

2.10 Organic chemistry

a) Functional groups. Structural isomers and stereoisomers (limited to geometric (E–Z) isomerism as a result of restricted rotation about a carbon–carbon double bond **and optical isomerism as a result of chirality in molecules with a single chiral centre**).

b) Reactions classified as: addition, elimination, substitution, oxidation, **reduction**, **hydrolysis**, addition polymerisation and **condensation polymerisation.**

c) Mechanisms classified as: radical substitution, electrophilic addition, nucleophilic substitution, **electrophilic substitution and nucleophilc addition.**

d) Single and double covalent bonds, bond polarity and bond enthalpy as factors influencing reactivity, illustrated by reference to appropriate reactions.

e) The structure of, and the bonding in, benzene.

f) Organic synthesis, including characteristic reactions of alkanes, alkenes, halogenoalkanes, alcohols, **arenes, aldehydes, ketones, carboxylic acids, esters, amines, amino acids and amides.**

2.11 Modern analytical techniques

a) The use of mass spectrometry, infrared spectroscopy, **nuclear magnetic resonance spectroscopy and chromatography** in analysis, including techniques for the elucidation of structure.

Appendix 3: Physics – Knowledge and understanding

This appendix must be read in conjunction with section 3 of the science criteria. The AS knowledge and understanding set out in this appendix should comprise approximately 60 per cent of the AS specification. The AS and A2 knowledge and understanding combined should comprise approximately 60 per cent of an A level specification. The A2 content is shown in bold.

3.1 All physics specifications should require students to develop:

- their knowledge of SI units
- an understanding of the distinction between vector and scalar quantities
- an awareness of the order of magnitude of physical quantities
- an awareness of the limitations of physical measurements.

3.2 All physics specifications must ensure that there is an appropriate balance between mathematical calculations and written explanations of principles.

3.3 Mechanics

a) Vectors	resolution into two components at right angles addition rule for two vectors calculations limited to two perpendicular vectors
b) Kinematics	graphical representation of uniform accelerated motion use of kinematic equations in one dimension with constant velocity or acceleration interpretation of speed and displacement graphs for motion
c) Dynamics	use of $F = ma$ when mass is constant One- and two-dimensional motion under constant force independent effect of perpendicular components with non-uniform acceleration
d) Energy	calculation of work done for constant forces, including force not along the line of motion calculation of exchanges between gravitational potential energy and kinetic energy
e) Momentum	**definition, equation** **principle of conservation of momentum** **calculations for one-dimensional problems**
f) Circular motion	**application of $F = ma = mv^2/r$ to motion in a circle at constant speed**
g) Oscillations	**simple harmonic motion** **quantitative treatment, limited to $a = -(2\pi f)^2x$ and the solution $x = A \cos 2\pi ft$** **velocity as gradient of displacement – time graph** **qualitative treatment of free and forced vibrations, damping and resonance**

3.6 Electric circuits

a) Current	electric current as rate of flow of charge, $I = \Delta q/\Delta t$

b)	DC circuits	conservation of charge and energy in simple circuits relationships between currents, voltages and resistances in series and parallel circuits potential divider circuits
c)	Emf and potential difference	definition of emf and concept of internal resistance potential difference in terms of energy transfer
d)	Resistance	definition resistivity Ohm's law as a special case power dissipated
e)	**Capacitance**	**definition** **energy of a capacitor** **quantitative treatment of discharge curves**
3.5	Waves	qualitative treatment of polarisation and diffraction path difference, phase and coherence graphical treatment of superposition and standing waves
3.6	**Matter**	
a)	**Molecular kinetic theory**	**ideal gases; $pV = NkT$** **absolute zero** **effect of temperature on average molecular kinetic energy energy of an ideal gas**
b)	**Internal energy**	**idea of internal energy** **energy required for temperature change = $mc\Delta\theta$**
3.7	Quantum and **nuclear physics**	
a)	Photons	photon model to explain observable phenomena evidence supporting the photon model
b)	Particles	Evidence supporting the quantum model for particles A study of particle diffraction would provide suitable depth of treatment
c)	**Nuclear decay**	**connections between nature, penetration and range of ionising particles** **evidence for existence of nucleus** **activity of radioactive sources** **modelling with constant decay probability leading to exponential decay; idea of half life** **nuclear changes in decay**
d)	**Nuclear energy**	**$E = mc^2$ applied to nuclear processes** **appreciation that $E = mc^2$ applies to all energy changes** **simple calculations relating mass difference to energy change.** **descriptions of fission and fusion processes.**
3.8	**Fields**	
a)	**Force fields**	**concept and definition** **Gravitational force and field for point (or spherical) masses**

		Electric force and field for point (or spherical) charges in a vacuum
		Uniform electric field
		similarities and differences between electric and gravitational fields
b)	**B-fields**	**force on a straight wire and force on a moving charge in a uniform field with field perpendicular to current or motion**
c)	**Flux and electromagnetic induction**	**concept and definition**
		Faraday's and Lenz's laws
		emf as equal to rate of change of magnetic flux and simple calculations

Appendix 4: Psychology – Knowledge and understanding

This appendix must be read in conjunction with section 3 of the science criteria. The AS knowledge and understanding set out in this appendix should comprise approximately 60 per cent of the AS specification. The AS and A2 knowledge and understanding combined should comprise approximately 60 per cent of an A level specification. The A2 content is shown in bold.

4.1 There are no prior knowledge requirements for AS level specifications in psychology.

4.2 AS and A level specifications must require candidates to have a basic understanding of the scope of different areas in psychology and the breadth of different approaches in psychology.

4.3 AS level specifications must require candidates to develop knowledge and understanding from all of the following areas of psychology:

- Cognitive
- Social
- Developmental
- Individual differences
- Biological.

4.4 AS level specifications must also require candidates to develop knowledge and understanding of research methods in psychology including:

- Methods and techniques for collection of quantitative and qualitative data including experimentation, observation, self report and correlation
- Experimental design including independent measures and repeated measures
- Descriptive statistics including measures of central tendency dispersion and graphical presentation of results

4.5 In 4.3 and 4.4 above, there is a minimum requirement to relate to the following:

a) specialist vocabulary and terminology
b) psychological theories, concepts and studies
c) ethical issues in psychology
d) the collection and analysis of both quantitative and qualitative data in psychology, including the use of descriptive statistics
e) the strengths and weaknesses of methods of research and investigation in psychology
f) the contribution of psychology to an understanding of individual, social and cultural diversity.

4.6 In addition to the AS level requirements, A level specifications must require candidates to further develop knowledge and understanding from at least two of the core areas (from cognitive, social, developmental, individual differences and biological psychology).
Candidates must have an understanding of the major approaches in psychology including cognitive, biological, behavioural and psychdynamic. Knowledge and understanding must be related to:

a) the applications and implications of psychology to cultural, social and contemporary issues
b) the interrelationship between different areas of psychology
c) the scientific nature of psychology
d) the selection and application of knowledge and understanding of theories, concepts and approaches to the solution of problems
e) the design and reporting of investigations and drawing valid conclusions from them
f) the collection and analysis of both quantitative and qualitative data including the use of inferential statistics
g) the selection and application of knowledge and understanding of principles and perspectives
h) an appreciation of issues and/or debates in psychology.

4.7 Examples of synoptic assessment tasks might include:

- A piece of written work, assessed through external examination in which the candidates draw on a range of theoretical approaches to consider a contemporary debate in psychology, for example, the issues of free will and determinism, or the controversies surrounding behavioural genetics.

- A piece of written work, assessed through external examination, in which the candidates use their knowledge and understanding of a range of psychological applications and concepts to suggest how a novel problem might be explained or dealt with, for example, they might consider what psychology can contribute to our understanding of car accidents.

- A piece of written work, assessed through external examination, in which the candidates consider a piece of psychological research and critique it by considering a range of other theoretical or methodological approaches to the same research issue. The critique might consider the connections and contrasts between a number of different approaches in psychology.

Appendix 5: Geology – Knowledge and understanding

This appendix must be read in conjunction with section 3 of the science criteria. The AS knowledge and understanding set out in this appendix should comprise approximately 60 per cent of the AS specification. The AS and A2 knowledge and understanding combined should comprise approximately 60 per cent of an A level specification. The A2 content is shown in bold.

5.1 All specifications must require students to develop:

a) a broad understanding of geological processes operating at a range of scales in space and time

b) geological investigation skills and knowledge and how these are applied in practical and/or field geology

c) a scientific understanding of the Earth, its evolution and its sustainable development.

5.2 Global tectonics

a) Evidence for the structure and composition of the Earth

b) Earthquakes

c) Geomagnetism

d) Continental drift, seafloor spreading

e) Plate tectonics

5.3 Surface processes and sedimentary rocks

a) Weathering, erosion and transport

b) Depositional processes

c) Lithification

5.4 Internal processes, igneous and metamorphic rocks

a) Magma generation

b) Igneous processes (intrusive / extrusive)

c) Metamorphism

d) Rock deformation, folds and faults

5.5 Geological time

Principles of dating

5.6 Geological data

Collection and interpretation of geological data including maps and photos, logs and other data.

5.7 Life on Earth

The nature, distribution, analysis and interpretation of fossils.

5.8 Earth materials and resources

Sustainability and environmental issues related to resources, including water and energy

5.9 Climate change

Evidence and impacts over varying timescales, past climates and their interpretation in the rock record.

Appendix 6: Electronics – Knowledge and understanding

This appendix must be read in conjunction with section 3 of the science criteria. The AS knowledge and understanding set out in this appendix should comprise approximately 60 per cent of the AS specification. The AS and A2 knowledge and understanding combined should comprise approximately 60 per cent of an A level specification. The A2 content is shown in bold.

6.1	System synthesis	recognise that simple systems consist of an input, a process, an output and possibly feedback analyse and design system diagrams represent complex systems in terms of sub-systems
6.2	Logic systems	identify and use NOT, AND, NAND, OR, NOR and EOR gates construct and recognise truth tables for these gates and simple combinations of them use combinations of one type of gate to perform other logic functions generate the Boolean expression for a system from a truth table simplify a logic system
6.3	Voltage (*V*), current (*I*) and resistance (*R*)	define resistance as *V*/*I* calculate the combined resistance of resistors connected in series and/or parallel
6.4	Power	define power as *VI* apply the formula to calculate power dissipation in a circuit
6.5	Resistive input transducers	describe the use of LDRs, negative temperature coefficient thermistors and switches in a voltage divider circuit to provide analogue signals interpret and use the characteristic curves of the above devices
6.6	Transistors	describe their use as switches
6.7	Diodes	describe the use of light-emitting diodes, silicon diodes and zener diodes and carry out relevant calculations
6.8	Output devices	describe the use of a buzzer, a loudspeaker, a motor and a seven-segment display in a system
6.9	Op-amps	recall the characteristics of an ideal op-amp and be aware that these may be different for a typical op-amp understand and explain the use of an op-amp in a comparator circuit

		recall how the output state depends on the relative value of the two input states draw and recognise an inverting amplifier circuit use the formula $\frac{V_{out}}{V_{in}} = -\frac{R_f}{R_{in}}$ draw and recognise a non-inverting amplifier circuit use the formula $\frac{V_{out}}{V_{in}} = 1 + \frac{R_f}{R_1}$
6.10	Timing circuits	explain how capacitors can be used to form the basis of timing circuits calculate the value of the time constant for RC circuits recall that a monostable circuit has one stable state and one unstable state recall that a monostable circuit can be used to form a simple time delay circuit recall that an astable circuit has two unstable states recall that an astable circuit can be used to form a simple pulse generator circuit
6.11	Sequential logic sub-systems	construct and use timing diagrams to explain the operation of sequential logic circuits; recall and describe the operation of a binary ripple up- counter design binary ripple up-counters that reset after *N* counts
6.12	**Microprocessor control systems**	**recall and describe a microprocessor control system as a programmable assembly of memory, input ports, output ports and interrupt inputs** **recall and explain the use of interrupts to allow an external device to be serviced on request** **recall and describe the application of a microprocessor control system.**
6.13	**Interfacing systems**	**explain the need for signal conversion between analogue and digital form in areas such as communication systems and microprocessor systems** **describe and explain how a DAC can be used to convert a digital signal into an analogue signal** **describe and explain how an ADC can be used to convert an analogue signal into a digital signal**
6.14	**Communication systems**	**recall that communication is the transfer of meaningful information from one location to another** **recall and describe the transfer of data by various**

		carriers and media **recall and explain the relationship between bandwidth, data rate and capacity to carry information** **explain the need to multiplex a number of signals onto one transmission medium** **describe the principles of frequency OR time division multiplexing** **recall and describe the difference between noise and distortion** **recall and describe how a Schmitt trigger can be used to regenerate a digital signal**
6.15	**Radio transmission**	**recall and explain the use of the radio spectrum for the transmission of different types of data** **describe and explain the use of one common method of modulation**
6.16	**Radio reception**	**describe and explain the function of the sub-systems within a simple radio receiver consisting of an aerial, tuned circuit, detector and earphone** **calculate the resonant frequency of a tuned circuit** **describe and explain how the sensitivity and selectivity of a simple radio receiver can be improved** **describe and explain the function of the sub-systems in a superhet radio receiver consisting of an aerial, rf amplifier, mixer, local oscillator, if filter, if amplifier, demodulator/detector, af amplifier and loudspeaker**

Appendix 7: Environmental science – Knowledge and understanding

This appendix must be read in conjunction with section 3 of the science criteria. The AS knowledge and understanding set out in this appendix should comprise approximately 60 per cent of the AS specification. The AS and A2 knowledge and understanding combined should comprise approximately 60 per cent of an A level specification. The A2 content is shown in bold.

7.1 AS and A level specifications must require candidates to develop knowledge and understanding of Earth's life-support systems and the principle of sustainability, the Earth's physical resources and their use, and to explore a range of environmental issues, making use of the scientific evidence available.

7.2 AS and A level specifications must require candidates to have an understanding of the breadth of different aspects of environmental science and to draw on the aspects of the wide range of sciences, including biology, chemistry, geology and physics. Candidates must have an understanding of how humans affect and interact with the environment.

7.3 Candidates must investigate the evidence for human impact on the environment (both positive and negative), environmental problems, solutions and their validity to enable informed discussion and decision-making.

Area of study

7.4 Biodiversity
7.5 Conservation
7.6 Energy, and renewable and non-renewable resources
7.7 Cycles and systems
7.8 Human population and resource exploitation balance
7.9 Pollution and wastes
7.10 Analysis of environmental risks associated with human activity
7.11 The approaches to the study of these areas must apply to both AS and A2 studies and include:

a) an exploration of the underlying science
b) an interdisciplinary focus
c) a study of the environmental impact of human activities
d) the use of relevant and contemporary examples to illustrate issues
e) a consideration of these areas on a range of different magnitudes and timescales.

Appendix 8: Mathematical content for science subjects

8.1 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 in 8.7 below.

8.2 Arithmetic and numerical computation

(a) recognise and use expressions in decimal and standard form
(b) use ratios, fractions and percentages
(c) make estimates of the results of calculations (without using a calculator)
(d) use calculators to find and use power, exponential and logarithmic functions
(e) use calculators to handle sin *x,* cos *x,* tan *x* when *x* is expressed in degrees or radians
(f) use hexadecimal and binary systems.

8.3 Handling data

(a) use an appropriate number of significant figures
(b) find arithmetic means
(c) construct and interpret frequency tables and diagrams, bar charts and histograms
(d) understand simple probability
(e) understand the principles of sampling as applied to scientific data
(f) understand the terms mean, median and mode
(g) use a scatter diagram to identify a correlation between two variables
(h) use a simple statistical test
(i) make order of magnitude calculations.

8.4 Algebra

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

8.5 Graphs

(a) translate information between graphical, numerical and algebraic forms
(b) plot two variables from experimental or other data
(c) understand that $y = mx + c$ represents a linear relationship
(d) determine the slope and intercept of a linear graph
(e) calculate rate of change from a graph showing a linear relationship
(f) draw and use the slope of a tangent to a curve as a measure of rate of change
(g) understand the possible physical significance of the area between a curve and the *x* axis and be able to calculate it or measure it by counting squares as appropriate
(h) use logarithmic plots to test exponential and power law variations
(i) sketch simple functions including $y = k/x$, $y = kx^2$, $y = k/x^2$, $y = \sin x$, $y = \cos x$, $y = e^{-x}$

8.6 Geometry and trigonometry

a) appreciate angles and shapes in regular 2-D and 3-D structures
b) visualise and represent 2-D and 3-D forms including two-dimensional representations of 3-D objects
c) understand the symmetry of 2-D and 3-D shapes
d) calculate areas of triangles, circumferences and areas of circles, surface areas and volumes of rectangular blocks, cylinders and spheres
e) use Pythagoras' theorem, and the angle sum of a triangle
f) use sin, cos and tan in physical problems
g) understand the relationship between degrees and radians and translate from one to the other.

8.7 Table of coverage:

	Appendix 1 Biology	Appendix 2 Chemistry	Appendix 3 Physics	Appendix 4 Psychology	Appendix 5 Geology	Appendix 6 Electronics	Appendix 7 Environmental science
8.2 a)	✓	✓	✓	✓	✓	✓	✓
b)	✓	✓	✓	✓	✓	✓	✓
c)	✓	✓		✓	✓		✓
d)	✓	✓	✓			✓	✓
e)			✓			✓	
f)						✓	
8.3a)	✓	✓	✓	✓	✓		✓
b)	✓	✓	✓	✓	✓		✓
c)	✓			✓	✓		✓
d)	✓			✓	✓		✓
e)	✓			✓	✓		✓
g)	✓			✓	✓		✓
h)	✓			✓	✓		✓
i)	✓			✓	✓		✓
j)			✓	✓	✓		✓
8.4a)		✓	✓	✓	✓	✓	✓
b)	✓	✓	✓			✓	
c)	✓	✓	✓	✓	✓	✓	✓
d)		✓	✓			✓	
e)		✓					
8.5a)	✓	✓	✓	✓	✓	✓	✓
b)	✓	✓	✓	✓	✓	✓	✓
c)		✓	✓		✓		✓
d)		✓	✓		✓	✓	
e)	✓	✓			✓		
f)		✓	✓			✓	
g)			✓				
h)			✓				
i)			✓				
8.6a)		✓					
b)		✓			✓		✓
c)		✓					
d)			✓		✓		✓
e)			✓				

f)			✓				
g)			✓				