GCE

Rewarding Learning

CCEA GCE Specification in

Life and Health Sciences

(Single Award and Double Award)

Version 2: 11 December 2017

For first teaching from September 2016
For first award of AS level in Summer 2017
For first award of A level in Summer 2018
Subject Code: 0008

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This specification is available online at www.ccea.org.uk

1 Introduction

This specification sets out the content and assessment details for our Advanced Subsidiary (AS) and Advanced GCE courses in Life and Health Sciences (Single and Double Award). First teaching is from September 2016.

We assess the AS units at a standard appropriate for students who have completed the first part of the full course. A2 units have an element of synoptic assessment (to assess students' understanding of the subject as a whole), as well as more emphasis on assessment objectives that reflect higher order thinking skills.

The full Single Award Advanced GCE is based on students' marks from the AS (40 percent) and the A2 (60 percent). The guided learning hours are:

- 180 hours for the Advanced Subsidiary level award; and
- 360 hours for the Advanced level award.

The full Double Award Advanced GCE is based on students' marks from the AS (40 percent) and the A2 (60 percent). The guided learning hours are:

- 360 hours for the Advanced Subsidiary level award; and
- 720 hours for the Advanced level award.

We will make the first AS awards for the specification in 2017 and the first A level awards in 2018. The specification builds on the broad objectives of the Northern Ireland Curriculum.

If there are any major changes to this specification, we will notify centres in writing. The online version of the specification will always be the most up to date; to view and download this please go to www.ccea.org.uk

1.1 Aims

This specification aims to encourage students to:

- develop their interest in and enthusiasm for science, including developing an interest in further study and careers in research science;
- appreciate how society makes decisions about scientific issues and how the sciences contribute to the success of the economy and society;
- develop competence in a range of practical, mathematical and problem solving skills;
- develop and demonstrate a deeper appreciation of the skills, knowledge and understanding of how science works;
- develop essential knowledge and understanding of different areas of the subject and how they relate to each other; and
- develop advanced study skills that help them prepare for higher education.

1.2 Key features

The following are important features of this specification.

- It includes 16 assessment units, some compulsory and some optional.
- The Single Award qualification at AS level comprises three units, and the full A level qualification has six units.
- The Double Award qualification at AS level comprises six units, and the full A level qualification has 12 units.
- The specification allows students to develop their subject knowledge, understanding and skills.
- It provides a firm grounding for students wishing to progress to higher education in life and health sciences or related subjects such as engineering or electronics.
- Assessment at A2 includes elements of synoptic assessment that encourage students to develop their understanding of the subject as a whole.
- Assessment at A2 is less structured and consequently stretches and challenges the students.
- A range of support is available, including specimen assessment materials, exemplar schemes of work and teacher guidance.

1.3 Prior attainment

Students do not need to have reached a particular level of attainment before beginning to study this specification. The specification builds on knowledge, understanding and skills developed in GCSE Single Award Science, GCSE Double Award Science and GCSE Sciences. The knowledge and understanding developed in GCSE Mathematics are also relevant.

1.4 Classification codes and subject combinations

Every specification has a national classification code that indicates its subject area. The classification code for this qualification is 0008.

Please note that if a student takes two qualifications with the same classification code, universities and colleges that they apply to may take the view that they have achieved only one of the two GCEs. The same may occur with any two GCE qualifications that have a significant overlap in content, even if the classification codes are different. Because of this, students who have any doubts about their subject combinations should check with the universities and colleges that they would like to attend before beginning their studies.

2 Specification at a Glance

The table below summarises the structure of the AS and A level courses. All AS units are available from Summer 2017 and A2 units from Summer 2018.

Content	Assessment	Single Award Weightings	Double Award Weightings
Unit AS 1: Experimental Techniques	Internal assessment Core unit	33.34% of AS 13.34% of A level	16.67% of AS 6.67% of A level
Unit AS 2: Human Body Systems	External written examination Core unit 1 hour 30 mins	33.33% of AS 13.33% of A level	16.67% of AS 6.67% of A level
Unit AS 3: Aspects of Physical Chemistry in Industrial Processes	External written examination Core unit 1 hour 30 mins	33.33% of AS 13.33% of A level	16.67% of AS 6.67% of A level
Unit AS 4: Brain Science	Internal assessment Core unit (Double Award)		16.66% of AS 6.66% of A level
Unit AS 5: Material Science	External written examination Core unit (Double Award) 1 hour 30 mins		16.67% of AS 6.67% of A level
Unit AS 6: Medicine, Drugs and Clinical Trials	Internal assessment Core unit (Double Award)		16.66% of AS 6.66% of A level

<table>
<tr><th>Content</th><th>Assessment</th><th>Single Award Weightings</th><th>Double Award Weightings</th></tr>
<tr><td>Unit A2 1:
Scientific Method, Investigation, Analysis and Evaluation</td><td>Internal assessment

Core unit</td><td>20% of A level</td><td>10% of A level</td></tr>
<tr><td>Unit A2 2:
Organic Chemistry</td><td>External written examination

1 hour 45 mins

Core unit</td><td>20% of A level</td><td>10% of A level</td></tr>
<tr><td>Unit A2 3:
Medical Physics</td><td rowspan="3">External written examination

1 hour 45 mins

Optional units</td><td rowspan="3">20% of A level

(Single Award students take any one of these units.)</td><td rowspan="3">10% of A level for each unit

(Double Award students take any two of these units.)</td></tr>
<tr><td>Unit A2 4:
Sound and Light</td></tr>
<tr><td>Unit A2 5:
Genetics, Stem Cell Research and Cloning</td></tr>
<tr><td>Unit A2 6:
Microbiology</td><td rowspan="5">Internal assessment

Optional units</td><td rowspan="5"></td><td rowspan="5">10% of A level for each unit

(Double Award students take any two of these units.)</td></tr>
<tr><td>Unit A2 7:
Oral Health and Dentistry</td></tr>
<tr><td>Unit A2 8:
Histology and Pathology</td></tr>
<tr><td>Unit A2 9:
Analytical Chemistry Techniques</td></tr>
<tr><td>Unit A2 10:
Enabling Technology</td></tr>
</table>

3 Subject Content

We have divided this course into 16 units: six units are available at AS level and 10 units at A2. This section sets out the content and learning outcomes for each unit.

At AS level, **all** students must complete:

- Unit AS 1: Experimental Techniques;
- Unit AS 2: Human Body Systems; and
- Unit AS 3: Aspects of Physical Chemistry in Industrial Processes.

In addition, students working towards a **Double Award** qualification must complete:

- Unit AS 4: Brain Science;
- Unit AS 5: Material Science; and
- Unit AS 6: Medicine, Drugs and Clinical Trials.

At A2, **all** students must complete:

- Unit A2 1: Scientific Method, Investigation, Analysis and Evaluation; and
- Unit A2 2: Organic Chemistry.

The **Single Award** qualification also includes any **one** of these three optional units and the **Double Award** includes any **two**:

- Unit A2 3: Medical Physics;
- Unit A2 4: Sound and Light; and/or
- Unit A2 5: Genetics, Stem Cell Research and Cloning.

In addition, the **Double Award** qualification includes any **two** of these five optional units:

- Unit A2 6: Microbiology;
- Unit A2 7: Oral Health and Dentistry;
- Unit A2 8: Histology and Pathology;
- Unit A2 9: Analytical Chemistry Techniques; and/or
- Unit A2 10: Enabling Technology.

3.1 Unit AS 1: Experimental Techniques

In this unit students develop skills in performing a range of experimental techniques useful in biology, chemistry and physics.

For each of the following scientific skills students must complete an investigation. They must present each investigation as a report that includes a title, objective, introduction, materials and apparatus, risk assessment, procedure, results and conclusion.

This unit is internally assessed; students complete a portfolio of evidence.

Content	Learning Outcomes
1.1 Chemistry skills	Students should be able to: 1.1.1 make a standard solution and use it to carry out a titration; 1.1.2 make suitable observations when carrying out qualitative chemistry tests, such as a flame test or the test for halide ions; 1.1.3 take suitable measurements to allow the calculation of a rate of reaction; 1.1.4 use standard techniques to prepare an organic compound and calculate a percentage yield;
1.2 Physics skills	1.2.1 determine the periodic time of an oscillating body; 1.2.2 determine the resistivity of a metal; 1.2.3 determine the focal length of a converging lens; 1.2.4 determine the critical angle for glass;
1.3 Biology skills	1.3.1 use qualitative reagents to identify biological molecules; 1.3.2 use a colorimeter to produce a calibration curve; 1.3.3 carry out chromatography of amino acids; and 1.3.4 carry out an osmosis experiment to investigate the impact of tonicity on osmosis.

3.2 Unit AS 2: Human Body Systems

This unit gives students the opportunity to learn about how human body systems work and how they support good health. A healthy body is fundamental to good quality of life. To maintain good health, a balanced diet that meets the energy and nutritional needs of the individual is key, as is regular physical exercise. Healthcare professionals perform assessments of how well human body systems are functioning. These assessments can, for example, provide information on whether an individual may have a disease or may need to make changes to their diet. In this unit students consider some health and fitness measurements used to monitor the activity of the body. They also investigate what is considered to be a healthy diet for different groups, for example children, the elderly and pregnant women.

This unit is assessed through an external examination consisting of a series of compulsory structured questions, some of which may allow opportunities for extended writing.

Content	Learning Outcomes
2.1 Cardiovascular system	Students should be able to: 2.1.1 describe the components and functions of the cardiovascular system; 2.1.2 demonstrate an understanding of the histological structure and function of arteries, veins and capillaries; 2.1.3 demonstrate an understanding of the structure and functioning of the heart; 2.1.4 demonstrate an understanding of heart sounds and the representation of the excitation wave in an electrocardiogram (ECG), including identifying a normal ECG trace and ECG traces for tachycardia, arrhythmia, ventricular fibrillation and bradycardia heartbeats and how these relate to physiological status; and 2.1.5 describe how to measure pulse rate (the typical range of pulse rate is 60–80 beats per minute) and blood pressure (using a sphygmomanometer), and know normal values for blood pressure for both genders for ages 18–40 years and how changes in these may relate to physiological status.

Content	Learning Outcomes
2.2 Respiratory system	Students should be able to: 2.2.1 describe the composition and functions of body fluids; 2.2.2 demonstrate an understanding of the chemical composition of haemoglobin in relation to its role in oxygen transport; 2.2.3 demonstrate an understanding of the concept of partial pressure of oxygen and its effect on oxygen transport by haemoglobin; 2.2.4 demonstrate an understanding of the Bohr effect on oxygen transport by haemoglobin and the physiological advantage of this for a tissue; 2.2.5 demonstrate an understanding of the structure and functioning of the components of the respiratory system – how these function individually and how the respiratory system functions as a whole – including how they are affected in conditions such as cystic fibrosis and emphysema; 2.2.6 demonstrate an understanding of the factors affecting the rate of gas exchange; 2.2.7 demonstrate an understanding of gas exchange in humans; and 2.2.8 demonstrate an understanding of and explain methods for monitoring the respiratory system – including how to measure breathing rate, tidal volume and vital capacity (using a spirometer) and peak expiratory flow rate (using a peak flow meter) – knowing average values for these indicators for males and females and how changes in these average values may relate to physiological status.

Content	Learning Outcomes
2.3 Respiration	Students should be able to: 2.3.1 describe the role that breathing plays in cellular respiration; 2.3.2 demonstrate an understanding that respiration involves chemical reactions that use oxygen; 2.3.3 describe how adenosine triphosphate, ATP, is produced by the process of aerobic respiration; 2.3.4 recognise the nature and function of ATP; 2.3.5 demonstrate an understanding of glycolysis; 2.3.6 demonstrate an understanding of aerobic respiration; 2.3.7 demonstrate an understanding of the Krebs cycle; 2.3.8 demonstrate an understanding of the electron transport chain; 2.3.9 compare aerobic and anaerobic respiration; 2.3.10 define what is meant by basal metabolic rate (BMR);
2.4 Homeostatic mechanisms and how these are monitored	2.4.1 describe the concept of homeostasis and the components of homeostatic mechanism; 2.4.2 describe the role of hormones in body function; 2.4.3 describe the regulation and monitoring of blood glucose levels – including the actions of insulin and glucagon – and the effects of food intake, physical activity and diabetes on insulin, glucagon and blood glucose levels; 2.4.4 explain the source, role and control of thyroxine; and 2.4.5 demonstrate an understanding of the homeostatic mechanisms involved in the regulation of sodium.

Content	Learning Outcomes
2.4 Homeostatic mechanisms and how these are monitored (cont.)	Students should be able to: 2.4.6 explain the importance of sodium ions and chloride ions in the healthy functioning of the body; 2.4.7 explain how blood is buffered to maintain normal blood pH range (7.35–7.45) and how blood pH is monitored; 2.4.8 describe the causes and consequences of blood becoming acidic or alkaline; 2.4.9 demonstrate an understanding of and explain the monitoring of oxygen saturation (SaO_2%; normal levels 90–95%) by pulse oximeter, how oxygen saturation is affected by blood pH and temperature, and the conditions which may lead to reduced SaO_2% levels, including cystic fibrosis, emphysema and pneumonia;
2.5 Nutrition and physical exercise in maintaining good health	2.5.1 demonstrate an understanding of the importance of a balanced diet and regular physical exercise in helping to maintain good health; 2.5.2 describe the composition of a balanced, healthy diet for an average person, including the proportions of different food groups; 2.5.3 describe the short-term and long-term benefits of a balanced, healthy diet; 2.5.4 demonstrate an understanding that body mass is gained or lost when the energy content of food taken in is more or less than the amount of energy expended by the body, how food intake and physical activity influence body mass, and the effects of being overweight and of obesity on short-, medium- and long-term health; and 2.5.5 collect, analyse and compare the composition of the diets of three or more individuals with a similar gender and age profile, critically evaluating their diets and classifying these as healthy or unhealthy.

Content	Learning Outcomes
2.5 Nutrition and physical exercise in maintaining good health (cont.)	Students should be able to: 2.5.6 compare the different nutritional and energy needs of babies, infants, young adults, pregnant women, adults and older people; 2.5.7 illustrate how a diet may need to be modified to suit the needs of specialist groups, for example diabetics, the overweight and obese, and older people; 2.5.8 describe the source, regulation and function of cholesterol, sodium, calcium, iron, and vitamins B, C, D and E; 2.5.9 summarise the monitoring of normal cholesterol levels (4.0–6.5 mmol/L) and the health effects of persistently high or low cholesterol; 2.5.10 explain how blood levels of iron, sodium and calcium are measured and monitored, the effects of deficiencies on health, and how these deficiencies may be rectified; 2.5.11 state normal levels of vitamins B, C, D and E, how these are monitored, the effects of deficiencies on health, and how these deficiencies may be rectified; 2.5.12 investigate current UK alcohol intake recommendations and the short-term and long-term health effects of alcohol consumption, including both positive (low–moderate consumption) and negative effects; and 2.5.13 evaluate short-term and long-term positive effects of regular physical exercise on general health, as well as cardiovascular and respiratory health.

3.3 Unit AS 3: Aspects of Physical Chemistry in Industrial Processes

In this unit students develop skills in performing calculations in chemistry. Students can also apply their knowledge of energetics, kinetics and equilibrium in the industrial manufacture of chemicals.

This unit is assessed through an external examination consisting of a series of compulsory structured questions, some of which may allow opportunities for extended writing.

Content	Learning Outcomes
3.1 Chemical calculations	Students should be able to: 3.1.1 use the chemical formula and relative atomic masses to calculate the relative formula mass of a substance, and the amount of a substance (moles) from its mass and vice versa; 3.1.2 construct and use balanced symbol equations to calculate required quantities of reactants, theoretical yields of products, percentage yield from experimental data and theoretical yield;
3.2 Volumetric analysis	3.2.1 describe the techniques and procedures used to prepare a standard solution of the required concentration; 3.2.2 demonstrate an understanding of the techniques and procedures used when carrying out acid-base titrations involving: • strong acid/strong base; • strong acid/weak base; and • weak acid/strong base (for example analysis of vinegar (ethanoic acid) or car battery acid (sulfuric acid)); 3.2.3 select the correct indicator for each type of titration and recall the colour change of phenolphthalein and methyl orange at the end point; and 3.2.4 select appropriate titration data, ignoring anomalies, to calculate mean titres.

Content	Learning Outcomes
3.2 Volumetric analysis (cont.)	Students should be able to: 3.2.5 calculate concentrations and volumes using titration data; 3.2.6 employ the term molarity, M, and the units of concentration, for example mol dm^{-3} ;
3.3 Energetics	3.3.1 demonstrate an understanding of the reasons why chemical reactions usually involve heat change; 3.3.2 contrast the terms exothermic and endothermic; 3.3.3 define the term standard enthalpy change (ΔH^{θ}); 3.3.4 recall standard conditions as 100 kPa and 298 K; 3.3.5 demonstrate knowledge of enthalpy changes in combustion and neutralisation reactions; 3.3.6 describe common experimental methods to determine the enthalpy change in a combustion and a neutralisation reaction; 3.3.7 recall and use the equation $Q=mc\Delta T$ to calculate enthalpy changes in a reaction; 3.3.8 explain the concept of the principle of conservation of energy; 3.3.9 define Hess's law; 3.3.10 construct simple enthalpy cycles and use these to carry out simple enthalpy change calculations; 3.3.11 explain the term average bond enthalpy; 3.3.12 use average bond enthalpies to calculate the enthalpy change of a reaction; and 3.3.13 account for the differences between theoretical and experimental bond enthalpy values.

Content	Learning Outcomes
3.4 Kinetics	Students should be able to: 3.4.1 define the terms rate of reaction and activation energy; 3.4.2 construct a reaction profile diagram; 3.4.3 explain the factors that affect the rate of a reaction, including concentration, pressure of gases, temperature and use of a catalyst; 3.4.4 explain common practical techniques to follow the rate of a reaction and analyse the effects of these factors; 3.4.5 demonstrate an understanding of collision theory; 3.4.6 recall and use the Maxwell–Boltzmann distribution curve to explain the effects of change in temperature and action of a catalyst on the rate of a given reaction; 3.4.7 describe the process of chemisorption in catalysis; 3.4.8 define the term catalyst and describe the role of a catalyst in a catalytic converter, including the concept of catalyst poisoning; 3.4.9 demonstrate an understanding of the use of a solid (heterogeneous) catalyst for industrial reactions; and 3.4.10 evaluate the economic benefits of using catalysts in industrial reactions, including the manufacture of ammonia, sulfuric acid and nitric acid.

Content	Learning Outcomes
3.5 Equilibrium	Students should be able to: 3.5.1 define the terms reversible reaction and dynamic equilibrium; 3.5.2 recall the conditions and equations required in the Haber process and the Contact process; 3.5.3 evaluate data to: • explain the need to reach a compromise between yield and rate of reaction for many industrial processes; and • be able to predict the effects of changes of temperature, pressure and concentration on the position of equilibrium;
3.6 Industrial processes	3.6.1 explain the terms batch and continuous process; 3.6.2 demonstrate an understanding that industry must take into account capital, direct and indirect costs when manufacturing chemicals on a large scale; 3.6.3 compare and contrast the differences between industrial scale and laboratory scale production of chemicals; 3.6.4 demonstrate an understanding of the economics linked to scaling up a laboratory reaction; 3.6.5 demonstrate an understanding of the link between production costs and determining the selling price of a chemical; and 3.6.6 consider the impact of waste management requirements as set out in *Required Environmental Information: A guide to supporting information required for effective consultations* (Northern Ireland Environment Agency, April 2015), along with other factors, on the choice of a site for a new chemical manufacturing plant.

3.4 Unit AS 4: Brain Science

In this unit students explore the science of the mind and the brain. They study the fundamentals of the structure of the brain, relevant physiological and psychological conditions, and research and technologies used in the field of neuroscience.

This unit is internally assessed; students complete a portfolio of evidence. They present this evidence in various forms including investigations, reports and fact sheets to demonstrate how they have achieved all the learning outcomes.

Content	Learning Outcomes
4.1 The healthy and the damaged brain	Students should be able to: 4.1.1 describe the structure of the brain, including the functions of the frontal lobes, temporal lobes, parietal lobes, occipital lobes, corpus callosum, ventricles, limbic system, basal ganglia and brain stem; 4.1.2 demonstrate an understanding of the function of sensory, relay and motor neurons, including calculating the speed at which a nerve impulse travels along one human arm; 4.1.3 explain the process of synaptic transmission, including neurotransmitters, excitation and inhibition; 4.1.4 demonstrate an understanding of the function of the endocrine system; 4.1.5 explain the role of adrenaline and experimentally investigate the effect of adrenaline production on a range of individuals; 4.1.6 describe the behavioural and cognitive effects of damage to frontal lobes; 4.1.7 demonstrate an understanding of the effect of Alzheimer's disease and Huntington's disease on the brain; and 4.1.8 describe stem cell therapy to treat neurodegenerative disease.

Content	Learning Outcomes
4.1 The healthy and the damaged brain (cont.)	Students should be able to: 4.1.9 describe the condition of schizophrenia, including the symptoms, biological explanations, genetics, the dopamine hypothesis, neural correlates, psychological explanations, and drug and cognitive therapies; 4.1.10 demonstrate an understanding of neural and hormonal mechanisms in aggression, including the roles of the limbic system, serotonin and testosterone, and genetic factors including the MAOA gene; 4.1.11 compare and contrast invasive and non-invasive methods of investigating brain function, including brain stimulation, lesion production, stereotaxic surgery and imaging techniques; 4.1.12 research and evaluate mental health awareness statistics, strategies and initiatives in Northern Ireland;
4.2 The physiological and psychological effects of stress	4.2.1 describe the physiology of stress, general adaptation syndrome, the hypothalamic–pituitary–adrenal system, the sympathomedullary pathway and the role of cortisol; 4.2.2 describe implications of stress on illness, including immunosuppression and cardiovascular disorders; 4.2.3 demonstrate an understanding of the causes of stress; 4.2.4 compare and contrast the psychological and physiological measurement of stress, including self-report scales and skin conductance response; and 4.2.5 evaluate stress treatments, including drug therapy, stress inoculation therapy and biofeedback.

Content	Learning Outcomes
4.3 Cognitive science	Students should be able to: 4.3.1 describe the multi-store model of memory, sensory register, short-term memory and long-term memory; 4.3.2 demonstrate an understanding of the features of each store – coding, capacity and duration; 4.3.3 describe types of long-term memory – episodic, semantic and procedural; 4.3.4 demonstrate an understanding of the working memory model – central executive, phonological loop, visuo-spatial sketchpad and episodic buffer; 4.3.5 compare explanations for forgetting – proactive and retroactive interference, and retrieval failure due to absence of cues; 4.3.6 describe factors affecting the accuracy of eyewitness testimony – misleading information, including leading questions and post-event discussion, and anxiety;
4.4 Psychopathology and treatment	4.4.1 demonstrate an understanding of definitions of abnormality, including deviation from social norms, failure to function adequately, statistical infrequency and deviation from ideal mental health; 4.4.2 explain the behavioural, emotional and cognitive characteristics of phobias, depression and obsessive-compulsive disorder (OCD); 4.4.3 describe the behavioural approach to explaining and treating phobias; 4.4.4 describe the cognitive approach to explaining and treating depression – Beck's Negative Triad, Ellis's ABC model and cognitive behavioural therapy (CBT), including challenging irrational thoughts; and 4.4.5 describe the biological approach to explaining and treating OCD – genetic and neural explanations, and drug therapy.

Content	Learning Outcomes
4.5 Research methods	Students should be able to: 4.5.1 compare and contrast the following types of experiment: • laboratory and field experiments; and • natural and quasi-experiments; 4.5.2 compare and contrast the following types of observation: • naturalistic and controlled observation; • covert and overt observation; and • participant and non-participant observation; 4.5.3 describe self-report techniques, construct questionnaires and conduct interviews (structured and unstructured); 4.5.4 collect and process quantitative and qualitative data and demonstrate an understanding of the distinction between quantitative and qualitative data collection techniques; 4.5.5 analyse the relationship between co-variables (correlation); 4.5.6 state aims and hypotheses for two specific investigations; 4.5.7 demonstrate, through investigation, an understanding of sampling: • the difference between population and sample; • sampling techniques; • bias; and • generalisation; 4.5.8 compare and contrast peer-produced experimental designs, repeated measures, independent groups and matched pairs; and 4.5.9 construct questionnaires, including open and closed questions, and design interviews.

Content	Learning Outcomes
4.5 Research methods (cont.)	Students should be able to: 4.5.10 demonstrate an understanding of variables – the manipulation and control of variables, including independent and dependent variables, applied to a range of specific practical investigations; 4.5.11 demonstrate an understanding of ethics, including: • an awareness of how the British Psychological Society's code of ethics influences decision-making; and • reviewing and debating current ethical issues in the design and conduct of psychological studies; 4.5.12 describe the role of peer review in the scientific process and complete a review of the experimental work of other students; 4.5.13 use descriptive statistics to process collected data: • measures of central tendency – mean, median and mode; • calculation of mean, median and mode; • measures of dispersion; • range and standard deviation; • calculation of range; and • calculation of percentages; 4.5.14 present and display quantitative data obtained from investigative study – graphs, tables, scattergrams and bar charts; and 4.5.15 demonstrate an understanding of normal and skewed distributions.

3.5 Unit AS 5: Material Science

In this unit students learn about a variety of physical properties that can be measured and used to describe and select different materials. They relate these properties to microscopic structure and investigate a variety of different material groups, ranging from biomaterials to nanostructures and semiconductors.

This unit is assessed through an external examination consisting of a series of compulsory structured questions, some of which may allow opportunities for extended writing.

Content	Learning Outcomes
5.1 Material properties	Students should be able to: 5.1.1 investigate practically a range of materials to demonstrate an understanding of how they are selected depending on their properties; 5.1.2 define chemical resistance, electrical conductivity, thermal conductivity, coefficient of friction, ductility, malleability, elasticity, tensile strength, stress, strain, the Young modulus, yield strength and plasticity; 5.1.3 conduct experiments to determine: • stress and strain; • the Young modulus; • hardness (Vickers method); and • electrical conductivity; 5.1.4 recall and use the equation: $\text{stress } (\sigma) = \frac{\text{force (F)}}{\text{cross-sectional area (A)}}$ 5.1.5 recall and use the equation: $\text{strain } (\varepsilon) = \frac{\text{change in length } (\Delta l)}{\text{original length } (l_o)}$ 5.1.6 recall and use the equation: $\text{the Young modulus (E)} = \frac{\text{stress } (\sigma)}{\text{strain } (\varepsilon)}$

Content	Learning Outcomes
5.1 Material properties (cont.)	Students should be able to: 5.1.7 interpret and draw conclusions about materials when presented with stress-strain graphs; 5.1.8 carry out and describe an experiment that will yield a stress-strain graph demonstrating plasticity; 5.1.9 demonstrate an understanding of the concepts of creep and fatigue strength; 5.1.10 recall and use the equation: $\text{Density } (\rho) = \frac{\text{Mass (m)}}{\text{Volume (V)}}$ 5.1.11 convert densities from non-common units for comparison purposes, for example comparing g cm^{-3} to kg l^{-1} ;
5.2 Categorising materials	5.2.1 investigate a range of general materials that can be grouped into distinct categories and be aware of metals, ceramics, glasses, polymers and composites; 5.2.2 give examples of materials in each of the categories investigated and justify their use in a range of situations;
5.3 Microscopic structure	5.3.1 label a diagram of a Bohr model atom (knowledge of sub-orbitals is not required); 5.3.2 describe how the properties of metals relate to microscopic structure; 5.3.3 describe how the properties of crystalline, amorphous and polymeric materials relate to microscopic structure; 5.3.4 demonstrate an understanding of the difference in microscopic structure between thermosetting and thermoplastics; and 5.3.5 explain typical uses of thermosetting and thermoplastics.

Content	Learning Outcomes
5.3 Microscopic structure (cont.)	Students should be able to: 5.3.6 describe how the properties of composite materials relate to microscopic structure; 5.3.7 investigate the crystal structure of a range of materials using a polarising light microscope;
5.4 Alloys and metal working	5.4.1 describe what an alloy is; 5.4.2 investigate practically and compare the physical properties of bronze, brass and stainless steel; 5.4.3 give examples of alloys, their constituent materials and common uses, including steel, stainless steel, invar, bronze, brass and nichrome; 5.4.4 describe the purpose and process of annealing; 5.4.5 analyse data relating to the constituent make-up of alloys and resulting properties to arrive at a decision about the suitability of a particular alloy for a given task;
5.5 Biomaterials	5.5.1 describe what is meant by biomaterial; 5.5.2 demonstrate an understanding of the differences between biotolerant, bioactive and bioinert biomaterials;
5.6 Smart materials	5.6.1 define a smart material and investigate the properties of a range of smart materials; 5.6.2 briefly outline the defining features of shape-memory alloys, piezoelectric materials, quantum-tunnelling composites, thermochromatic materials, photochromatic materials and electroluminescent materials; and 5.6.3 apply knowledge of smart material features to specific situations.

Content	Learning Outcomes
5.7 Nanomaterials	Students should be able to: 5.7.1 describe the structure of graphite, graphene and a carbon nanotube; 5.7.2 demonstrate an understanding of the physical properties of carbon nanotubes; 5.7.3 evaluate the potential uses for carbon nanotubes in healthcare (for example nitric oxide sensors, drug loading capacity, selective cancer cell destruction, bio-stress sensors, glucose detection biosensors and scaffolding for tissue regeneration); 5.7.4 evaluate the benefits and risks of nanotechnology to society;
5.8 Semiconductors	5.8.1 demonstrate an understanding of how the electron configuration of silicon makes it an excellent semiconductor material; 5.8.2 describe briefly how n-type and p-type doping allow current flow in doped silicon; 5.8.3 apply their knowledge of doping to briefly explain diode behaviour; and
5.9 Industrial considerations	5.9.1 evaluate the external factors that influence the choice of material for a particular situation – price, environmental considerations, quality required, demand and regulations.

3.6 Unit AS 6: Medicine, Drugs and Clinical Trials

In this unit students explore the problems associated with developing new medicines and how these must be controlled. They consider the role of medicines and their importance in everyday life. They also investigate how different medicines are developed and trialled by the pharmaceutical industry and synthesised from chemical and natural sources. They discover the importance of maintaining high standards in the quality of a medicine. They also evaluate the safety and effects of medicine and the need for monitoring.

This unit is internally assessed; students complete a portfolio of evidence.
The portfolio must include two reports, one on each of the following:

- the quantitative analysis of a medicine; and
- the bioassay of the medicines outlined in 6.4.2 below.

Content	Learning Outcomes
6.1 Categories of medicine	Students should be able to: 6.1.1 define what a drug/medicine is; 6.1.2 categorise medicines according to their purpose, for example antibiotic or antiviral; and 6.1.3 demonstrate knowledge and understanding of methods of developing new drugs, including: • accidental discovery; • demand for a particular medicine; • deriving modern drugs from traditionally used ones; • observing wildlife and plants, for example tropical plants (because of their great diversity); • using chemical fingerprinting technology to more effectively screen chemicals for their natural medicinal properties; • genetics; • studying how pathogenic microorganisms interact with human cells; and • synthetic drugs in the laboratory.

Content	Learning Outcomes
6.2 Medicines from concept to consumer	Students should be able to: 6.2.1 choose one modern day medicine that has been derived from natural sources – for example Yondelis, Taxol, Digitoxin, aspirin, penicillin, Paclitaxel, Tiotropium or Heparin; 6.2.2 outline the processes used to develop their chosen medicine; 6.2.3 include the following in their portfolio: • a description of how medicines are named according to the Anatomical Therapeutic Chemical (ATC) Classification System; • an explanation of nomenclature of medicines (both in general and specific to their chosen medicine); and • the chemical name and structure of their chosen medicine (highlighting functional groups), and its generic and trade names; and 6.2.4 include the following in their portfolio: • where their chosen medicine originally came from; • how they would categorise it according to its action; • the extraction and refinement process for the drug; • stages in drug development from pre-discovery to launch; • the factors that impact the design of a clinical trial; • how trials are put together to ensure that the only factor which changes is intervention, including preclinical in vitro and in vivo trials, pharmacology and toxicology testing, and ED50 and lethal dose LD50; • how clinical trials ensure that clinical decisions are based on the best available evidence, including types of trials and trial protocol; and • how clinical trial results are grouped together from different cohorts in order to increase the evidence base.

Content	Learning Outcomes
6.2 Medicines from concept to consumer (cont.)	Students should be able to: 6.2.5 investigate, interpret and evaluate the performance criteria laid out when a new medicine is developed and trialled; 6.2.6 describe the development and testing process that a medicine goes through before a licence is issued and the product is launched; 6.2.7 describe the roles and responsibilities of manufacturers; 6.2.8 describe the roles and responsibilities of the UK regulatory bodies; 6.2.9 discuss and evaluate the various possible formulations of medicines and the pros and cons of each, including: • the monitoring of black triangle drugs using the yellow card scheme; and • the side effects and contraindications of medicines; and 6.2.10 summarise the ethical issues, patient consent and safety guidelines associated with the development of their chosen medicine.

Content	Learning Outcomes
6.2 Medicines from concept to consumer (cont.)	Students should be able to: 6.2.11 for their chosen medicine, investigate and discuss: • pharmacodynamics – the study of how chemicals exert their effects; • pharmacokinetics – how much of the drug should be used to get the desired effect without getting unwanted effects; • the dose – relating it to the therapeutic index, and how appropriate dosing is determined; • administration – the mechanism by which a drug enters the body, describing the methods of administration of medicines, highlighting the advantages and disadvantages; • absorption – how a drug is assimilated into the body, for example by disintegration, dissolution or direct absorption at the site of action; • distribution and metabolism – – how the medicine is transported, distributed and metabolised by the body; – factors that affect distribution, including binding to plasma proteins, extent of blood supply, binding of drugs to other tissue components, and pH; and – factors that affect how much of a medicine is metabolised; and • elimination – how the drug is removed from the body and factors affecting how drugs are excreted from the body, including individual variation;
6.3 Actions of medicines in the body relating to functionality	6.3.1 explain, for their chosen medicine: • factors that affect the action of the medicine, including functional groups, molecular structure and elimination (via excretion or metabolism) from the body; and • the site of action, for example organs, cell membranes, muscles, blood or the nervous system; and 6.3.2 describe the factors that affect the actions of their chosen medicine within the body.

Content	Learning Outcomes
6.4 Analysis of medicines through quantitative analysis and bioassays	Students should be able to: 6.4.1 report on the quantitative analysis of a chosen medicine and bioassay from 6.4.2; 6.4.2 research suitable methods for quantitative analysis, for example one of the following: • determining the percentage purity of aspirin in over-the-counter aspirin tablets via back titration; or • determining the amount of iron present in an iron tablet via titration with potassium permanganate; and one of the following: • the effect of ampicillin on bacterial growth; or • the effect of different concentrations of an antibacterial agent on bacterial growth; 6.4.3 refer to appropriate background scientific principles in their portfolio; 6.4.4 describe in detail the practical procedures to be used; 6.4.5 select appropriate equipment and use it safely; 6.4.6 demonstrate precision to carry out their analysis effectively; 6.4.7 demonstrate evidence of working with relative autonomy; 6.4.8 carry out comprehensive, detailed and accurate risk assessments; 6.4.9 obtain complete and accurate results; and 6.4.10 evaluate and justify the method(s) they used and discuss how these could be improved.

3.7 Unit A2 1: Scientific Method, Investigation, Analysis and Evaluation

In this unit students have the opportunity to demonstrate an understanding of what makes an investigation scientific. They carry out research and get to choose, plan and undertake a scientific investigation. They will communicate their results and conclusions, and evaluate their work.

This unit is internally assessed; students complete a portfolio of evidence that includes an essay, plans, a lab book, and a report with analysis and evaluation.

Content	Learning Outcomes
7.1 The scientific method	Students should be able to: 7.1.1 demonstrate an understanding of what makes an investigation scientific: • demonstrate an understanding of negative results; • generate ideas for the areas in science that interest them and for associated experimental work; • identify factors that make a good scientific investigation; and • state their choice of area for experimental research; 7.1.2 demonstrate an understanding of the requirements for technical writing in scientific communication; 7.1.3 use information resources: • identify, locate and extract relevant information from up to 10 sources; and • use the Harvard system to reference the sources; 7.1.4 demonstrate knowledge of statistical concepts including mean, median, mode, variance, standard deviation, normal distribution, inferential statistics, null hypothesis, alternative hypothesis, significance, probability and confidence levels: • choose a statistical test; and • use a computer spreadsheet for descriptive statistics; and 7.1.5 demonstrate an understanding of Design of Experiment (DoE), using a computer spreadsheet to produce results, if applicable.

Content	Learning Outcomes
7.1 The scientific method (cont.)	Students should be able to: 7.1.6 ensure the quality of their investigation: • Good Laboratory Practice (GLP); • Good Manufacturing Practice (GMP); • Good Clinical Practice (GCP); and • use of checklists; 7.1.7 demonstrate an understanding of health and safety requirements: • risk assessment; • elimination or minimisation of identified risks; and • physical resources;
7.2 Scientific investigation	7.2.1 choose a suitable scientific investigation; 7.2.2 write a referenced literature review, analysing the research information and discussing its relevance to the planned experiment; 7.2.3 use investigation design principles: • formulate an aim (or aims); • identify independent and dependent variables; • write a hypothesis; • evaluate different approaches considered for the investigation, justifying the hypothesis chosen; • state proposed analytical techniques to be used; • assess possible errors in practical work; • assess health and safety – identify hazards, perform a risk assessment, record risk control in the laboratory and perform a Control of Substances Hazardous to Health (COSHH) assessment (where necessary); • identify any ethical issues; • identify resources and how they will obtain them; • identify any training needs for using new equipment or techniques; and • identify milestones; and 7.2.4 produce a draft project plan.

Content	Learning Outcomes
7.2 Scientific investigation (cont.)	Students should be able to: 7.2.5 conduct a trial of the experimental work: • define the method; • analyse results; and • review and update all aspects of the project plan; 7.2.6 produce a realistic project plan for a scientific investigation: • conduct a scientific investigation; • keep a record of health and safety protocol; • describe the use of equipment and/or lab techniques; • demonstrate GLP; and • ensure accuracy and precision of results;
7.3 Scientific analysis	7.3.1 perform scientific analysis, taking into account: • organisation of data; • statistical analysis; • units and dimensions; • assessment of accuracy and precision; • reproducibility and reliability; and • errors and how to reduce them;
7.4 Scientific evaluation	7.4.1 present results and statistical data analysis in an appropriate format; 7.4.2 state a conclusion; and 7.4.3 produce a scientific evaluation.

3.8 Unit A2 2: Organic Chemistry

In this unit students focus on basic reactions within organic chemistry. We have divided the unit of work into three distinct areas: nomenclature, structure and isomerism within organic compounds; uses of alkanes, alkenes and alcohols in industry; and common polymers, their uses and safe disposal.

Students consider the uses of organic compounds in contributing to an increasing carbon footprint. They also develop an understanding of the preparation of a simple organic compound and evaluate its purity.

This unit is assessed through an external examination consisting of a series of compulsory structured questions, some of which may allow opportunities for extended writing.

Content	Learning Outcomes
8.1 Nomenclature, structure and isomerism in organic compounds	Students should be able to: 8.1.1 demonstrate an understanding that a hydrocarbon is composed of carbon and hydrogen only; 8.1.2 demonstrate an understanding of the terms empirical and molecular formula and the relationship between them; 8.1.3 represent organic molecules according to structural, skeletal, molecular and general formulae; 8.1.4 calculate empirical and molecular formulae using data, giving composition by mass; 8.1.5 demonstrate an understanding of the terms structural formulae, homologous series and functional groups; 8.1.6 apply International Union of Pure and Applied Chemistry (IUPAC) rules to naming organic compounds with up to six carbon atoms; 8.1.7 classify reactions for molecules up to six carbon atoms long as addition, elimination, substitution, oxidation, reduction, hydrolysis or polymerisation; and 8.1.8 describe and explain structural isomerism for aliphatic compounds containing up to six carbon atoms.

Content	Learning Outcomes
8.1 Nomenclature, structure and isomerism in organic compounds (cont.)	Students should be able to: 8.1.9 determine the possible structure and skeletal formulae of an organic molecule given its molecular formula; 8.1.10 demonstrate an understanding of how stereoisomers (geometrical isomers) exist for alkenes in cis and trans (E−Z) forms due to the energy barrier to rotation in these compounds (where two of the substituent groups are the same);
8.2 Hydrocarbons – alkanes	8.2.1 write the general formulae for alkanes as C_nH_{2n+2} ; 8.2.2 demonstrate an understanding and explain that alkanes and cycloalkanes are saturated compounds; 8.2.3 recall the structural and molecular formulae for alkanes with up to six carbon atoms; 8.2.4 demonstrate an understanding that alkane fuels are obtained from the fractional distillation, cracking and reforming of crude oil; 8.2.5 apply IUPAC rules to naming alkanes with up to six carbon atoms; 8.2.6 describe the following reactions using balanced symbol equations: • the combustion of alkanes in both limited and plentiful supplies of air; and • the substitution reaction between methane and halogens; 8.2.7 state that pollutants including carbon monoxide, oxides of nitrogen and sulfur, carbon particulates and unburned hydrocarbons are formed during the combustion of alkane fuels; and 8.2.8 discuss the environmental problems associated with spillage and combustion of hydrocarbons.

Content	Learning Outcomes
8.2 Hydrocarbons – alkanes (cont.)	Students should be able to: 8.2.9 demonstrate an understanding of how using a catalytic converter solves some problems caused by vehicle emissions by allowing the conversion of carbon monoxide to carbon dioxide and water, and of NO_x to nitrogen; 8.2.10 demonstrate an understanding of the use of alternative fuels, including alcohol and biodiesel derived from renewable sources such as plants, comparing these with non-renewable fossil fuels;
8.3 Hydrocarbons – alkenes	8.3.1 write the general formulae for alkenes as C_nH_{2n} ; 8.3.2 demonstrate an understanding and explain that alkenes and cycloalkenes are unsaturated compounds and that they decolourise bromine water (qualitative test required); 8.3.3 recall the structural and molecular formulae for alkenes with up to six carbon atoms; 8.3.4 apply IUPAC rules to name alkenes with up to six carbon atoms; and 8.3.5 demonstrate an understanding of the bonding in alkenes in terms of sigma and pi bonds.

Content	Learning Outcomes
8.3 Hydrocarbons – alkenes (cont.)	Students should be able to: 8.3.6 demonstrate an understanding of and write appropriate balanced symbol equations for: • the addition reactions of alkenes with hydrogen in the presence of a nickel catalyst, to form an alkane (knowledge of the application of catalytic hydrogenation to the manufacture of margarine is expected; however, detailed structure of the oil molecule is not expected); • the reaction between hydrogen bromide, ethene and halogens to produce mono- or di-halogenoalkanes viewed as an electrophilic addition mechanism; • the hydration of alkenes using steam in the presence of a catalyst to produce alcohols; and • the addition polymerisation of alkenes, including ethene and propene;
8.4 Alcohols	8.4.1 explain that alcohols can be classified as primary, secondary or tertiary; 8.4.2 write the general formulae of alcohols as $C_nH_{2n+1}OH$; 8.4.3 recall molecular and structural formulae with up to six carbons (referring to primary, secondary and tertiary structures); 8.4.4 apply IUPAC rules to name alcohols with one hydroxyl group and up to six carbon atoms; 8.4.5 describe the preparation of alcohols from halogenoalkanes; 8.4.6 describe the industrial preparation of alcohol from: • the reaction of steam with ethene in the presence of phosphoric acid; and • the fermentation of sugars to make ethanol; and 8.4.7 discuss the use of ethanol in alcoholic beverages and its use as a recreational drug which can have beneficial and harmful effects.

Content	Learning Outcomes
8.4 Alcohols (cont.)	Students should be able to: 8.4.8 use balanced symbol equations for the reactions of alcohols with: • concentrated phosphoric acid to form alkenes by elimination (mechanism of reaction not expected); and • potassium dichromate (VI) in dilute sulfuric acid to oxidise primary alcohols to aldehydes and carboxylic acids, and secondary alcohols to ketones (using Benedict's or Fehling's solution to test for the aldehyde);
8.5 Polymers	8.5.1 demonstrate an understanding that addition polymers are made from molecules containing C=C bonds; 8.5.2 demonstrate an understanding that polythene is chemically inert and this leads to a need for waste management strategies, including: • incineration to release energy; • recycling; and • using it as feedstock for cracking; 8.5.3 evaluate how chemists can limit the problems linked to polymer disposal by: • removing toxic waste gases caused by the incineration of plastics; and • continuing to develop biodegradable polymers; and
8.6 Spectroscopic techniques	8.6.1 demonstrate an understanding of how a combination of infrared (IR) spectroscopy and mass spectrometry can be used to identify organic compounds;

Content	Learning Outcomes
8.7 Making and purifying organic compounds – the preparation of aspirin	Students should be able to: 8.7.1 investigate the main steps in the production and recrystallisation of laboratory grade aspirin; 8.7.2 determine the purity of laboratory synthesised aspirin using ferric chloride; 8.7.3 determine the theoretical and actual percentage yield from a laboratory prepared sample of aspirin; 8.7.4 determine the melting point of laboratory synthesised aspirin compared to industrially prepared aspirin; 8.7.5 suggest and explain any modifications they would make to their method and/or the product to improve its quality and/or yield; and
8.8 Making nylon	8.8.1 describe the process of condensation polymerisation to produce nylon.

3.9 Unit A2 3: Medical Physics

This unit enables students to appreciate the physical principles used in healthcare applications for medical monitoring, diagnosis and treatment. The unit includes physiological measurement, invasive and non-invasive imaging techniques and the medical use of radioactive isotopes. Students develop an understanding of the principles and techniques, the effectiveness of the applications, and health and safety considerations.

This unit is assessed through an external examination consisting of compulsory structured questions, some of which allow opportunities for calculation and extended writing.

Content	Learning Outcomes
9.1 Physiological measurements to monitor health	Students should be able to: 9.1.1 demonstrate an understanding of body temperature measurements and compare commonly used thermometers that measure body temperature; 9.1.2 demonstrate an understanding of the range of temperatures over which the body can survive; 9.1.3 demonstrate an understanding of the measurement of blood pressure; 9.1.4 demonstrate an understanding of the sphygmomanometer and investigate its use to collect and evaluate data; 9.1.5 scrutinise a range of blood pressure values and analyse them with reference to normal values of blood pressure; 9.1.6 develop an experiment to monitor heart activity effectively and compare this critically to the uses of the electrocardiogram (ECG); 9.1.7 demonstrate an understanding of how brain activity can be monitored and explore how the electroencephalogram (EEG) can be used to monitor brain activity; and 9.1.8 recognise typical EEG traces and illustrate their use in diagnosing brain conditions.

Content	Learning Outcomes
9.2 Diagnostic imaging techniques	Students should be able to: 9.2.1 describe the physical principles and application of, and the equipment used in, the following diagnostic imaging techniques: • conventional X-rays; • computerised tomography (CT) scans; • the flexible endoscope, including the use of lasers and optical fibres; • ultrasonic A-scans and B-scans; • magnetic resonance imaging (MRI) scans; and • conventional gamma ray imaging; 9.2.2 recall that the properties of X-rays are ionising radiation of high energy and high frequency and that they are part of the electromagnetic spectrum; 9.2.3 demonstrate an understanding of the functions of the main components in an X-ray tube; 9.2.4 recall that X-rays are absorbed more by tissues of high density than by tissues of low density; 9.2.5 demonstrate an understanding of the operation of an optical fibre in the context of endoscopy; 9.2.6 demonstrate an understanding of the terms coherent and incoherent bundles in endoscopes; 9.2.7 recall that a practical endoscope requires several channels, including a channel for target illumination, image collection, irrigation and surgical tools; and 9.2.8 define specific acoustic impedance, Z, as the product of the density of the tissue and the speed of sound in that tissue, and calculate its numerical value.

Content	Learning Outcomes
9.2 Diagnostic imaging techniques (cont.)	Students should be able to: 9.2.9 define the intensity reflection coefficient, R, between tissues of different specific acoustic impedance Z_1 and Z_2 as $$R = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2$$ and use the equation to calculate R; 9.2.10 recall that, while ultrasound has a frequency greater than 20 kHz, the frequency of the ultrasound used in medical imaging typically lies between 1 MHz and 18 MHz; 9.2.11 recall that deep structures such as liver and kidney are imaged at lower frequencies (1–6 MHz), which give greater penetration than high frequencies but cannot resolve fine structures; 9.2.12 recall that structures nearer the surface such as the breast and thyroid glands are imaged at higher frequencies (7–18 MHz) because they do not have to penetrate deeply into the body, and these can resolve fine structures; 9.2.13 demonstrate an understanding that the intensity reflection coefficient, R, is a measure of the fraction of the incident sound energy which is reflected; and 9.2.14 demonstrate an understanding of the need for a gel between the ultrasound probe and the skin to allow ultrasound waves to be transmitted into and out of the body without large energy loss.

Content	Learning Outcomes
9.3 Medical uses of radiation	Students should be able to: 9.3.1 investigate the use and detection of the types of radiation used in medicine for diagnosis and therapy; 9.3.2 demonstrate an understanding of properties of alpha (α), beta (β) and gamma (γ) radiation; 9.3.3 identify the dangers of each type of radiation; 9.3.4 investigate experimentally, or develop a mathematical model of, the process of radioactive decay; 9.3.5 recall that the activity, A, of a radioactive material is measured in Becquerel (Bq) and that 1 Bq represents one disintegration in a second; 9.3.6 define the physical half-life of a radioactive material as the time taken for the activity of that material to decrease to half of its original activity; 9.3.7 recall that the physical half-life of a radionuclide, $T_{1/2}$, is related to the decay constant, λ, by the equation $T_{1/2} = 0.693 / \lambda$; 9.3.8 observe and describe an experiment to determine the half-life of protactinium; 9.3.9 define biological half-life of a radioisotope as the time it takes for half of that radioisotope to be removed from the body by natural metabolic processes; 9.3.10 categorise the uses of radiation in medical diagnosis and treatment; and 9.3.11 critically evaluate the precautions taken by medical physicists when using radiation.

Content	Learning Outcomes
9.3 Medical uses of radiation (cont.)	Students should be able to: 9.3.12 compare the use of different radiopharmaceuticals and evaluate their specific properties which enable their use in diagnostic nuclear medicine, including: • technetium-99 – a gamma emitting radioactive tracer used in medical imaging; • rubidium-82 – a pharmaceutical rapidly taken up by the heart muscle and used in positron emission tomography (PET) perfusion imaging; and • thallium-201 in the form of thallium chloride for cardiac imaging and the detection of cancers; 9.3.13 demonstrate an understanding of how the medical use of radiation contributes to the background count; 9.3.14 demonstrate an understanding of how background radiation is taken into account in experimental investigation; and 9.3.15 recall and use the equations for radioactive decay $A = A_o e^{-\lambda t}$ and $\ln A = \ln A_o - \lambda t$ and use these equations to calculate A (activity at time t), Ao (original activity), λ (decay constant) and t (elapsed time).

3.10 Unit A2 4: Sound and Light

In this unit students learn about some of the underlying principles of wave mechanics and how these mechanics interact with human activity. They investigate human hearing and sight, the subjective nature of hearing, and vision correction. Learners also explore and appreciate how light is used in communication and how radio waves are useful in everything from television to wi-fi and object ranging.

This unit is assessed through an external examination consisting of a series of compulsory structured questions, some of which may allow opportunities for calculation and extended writing.

Content	Learning Outcomes
10.1 Waves	Students should be able to: 10.1.1 differentiate between transverse and longitudinal waves, and manipulate computerised simulations of these wave forms, such as in Virtual Physics Laboratory; 10.1.2 recognise examples of transverse and longitudinal waves; 10.1.3 calculate amplitude and wavelength from displacement-displacement graphs; 10.1.4 explain time period from displacement-time graphs and how it relates to the frequency of the wave; 10.1.5 calculate wave speed, recalling and using $v = f\lambda$; 10.1.6 calculate frequency from time period; 10.1.7 demonstrate an understanding of the concept of phase difference; 10.1.8 calculate the phase difference between two waves of identical wavelength and speed; 10.1.9 appreciate that visible light is a constituent part of the electromagnetic spectrum; and 10.1.10 compare the similar features of electromagnetic spectrum waves.

Content	Learning Outcomes
10.2 The ear	Students should be able to: 10.2.1 describe the function of the main parts of the outer ear, including: • pinna (auricle); • auditory canal; and • tympanic membrane (ear drum); 10.2.2 describe the function of the main parts of the middle ear, including: • ossicles – malleus, incus and stapes; and • Eustachian tube; 10.2.3 describe the function of the main parts of the inner ear, including: • oval window; • cochlea; • auditory nerve; and • semi-circular canals;
10.3 Sound measurement	10.3.1 explain sound intensity and state its units as W m^{-2} ; 10.3.2 perform an experiment to investigate their personal threshold intensity and state the threshold intensity, I_0, for human hearing as 1x10^{-12}W m^{-2} ; 10.3.3 recall and use the equation: $$\text{db level} = 10 \log_{10} \frac{I}{I_0}$$ 10.3.4 recall and use the arrangement of 10.3.3 as: $$I = I_0 \times 10^{\frac{\text{db level}}{10}}$$ 10.3.5 demonstrate an understanding of the logarithmic nature of the decibel scale, that each increase of 10 corresponds to a 10-fold increase in intensity; and 10.3.6 demonstrate an understanding of the reasons why a logarithmic scale is useful, as human hearing covers a wide range of intensities.

Content	Learning Outcomes
10.3 Sound measurement (cont.)	Students should be able to: 10.3.7 recognise that identical changes in decibel level correspond to identical fractional changes in intensity;
10.4 Standing waves	10.4.1 demonstrate an understanding of how a standing wave can be created when two identical waves travel in opposite directions and describe an experiment to demonstrate the phenomenon; 10.4.2 appreciate that when a standing wave is created there is an increase in amplitude and this is called resonance; 10.4.3 distinguish between node and antinode positions in a standing wave; 10.4.4 draw different standing wave harmonics on a stretched string or closed pipe; 10.4.5 calculate wavelength from a standing wave diagram; 10.4.6 perform and evaluate an experiment to measure the speed of sound using a resonance tube;
10.5 Hearing response	10.5.1 perform an experiment to measure the most sensitive frequency for human hearing; 10.5.2 demonstrate an understanding of how hearing response is frequency dependent and that maximum sensitivity occurs between 3 and 4 kHz and corresponds to resonance in the auditory canal; 10.5.3 appreciate that, due to 10.5.2, loudness is a subjective measure; 10.5.4 interpret graphs of frequency and intensity response for the ear; and 10.5.5 demonstrate an understanding of what a phon is and how it can be established experimentally.

Content	Learning Outcomes
10.5 Hearing response (cont.)	Students should be able to: 10.5.6 interpret and explain equal loudness curves on frequency-intensity response graphs; 10.5.7 demonstrate an understanding of hearing aids and that they consist of a microphone, amplifier and loudspeaker;
10.6 The eye	10.6.1 label a diagram of the eye, including the lens, cornea, pupil, iris, ciliary muscles, retina, macula, fovea, optic nerve, aqueous humour and vitreous humour; 10.6.2 describe the functions of each of the constituent parts of the eye in 10.6.1; 10.6.3 demonstrate an understanding of the function of rod and cone cells; 10.6.4 appreciate why two eyes allow stereoscopic vision and three-dimensional sight; 10.6.5 describe accommodation to focus on near and distant objects; 10.6.6 use the lens equation to calculate the optical power of a lens; 10.6.7 carry out experiments to find the optical power of a lens; 10.6.8 given the lens power, use the lens equation to find either the object or image distance; and 10.6.9 practically determine the normal near point for human vision and use this in calculations to correct long sight.

Content	Learning Outcomes
10.7 Light in communication	Students should be able to: 10.7.1 perform an experiment to measure the critical angle of a semi-circular glass block and investigate the conditions required for total internal reflection; 10.7.2 describe how total internal reflection can be used in optical communication; 10.7.3 describe the structure of a fibre-optic cable; 10.7.4 demonstrate an understanding of the difference between single mode and multi-mode fibres; 10.7.5 contrast the uses for single mode and multi-mode fibres;
10.8 Radio waves	10.8.1 discover how radio signals can be created using a dipole antenna and then intercepted by a receiving antenna and decoded; 10.8.2 apply this principle to describe broadly how wireless and Bluetooth technologies work; 10.8.3 describe the main action of radio waves in radar systems; 10.8.4 demonstrate an understanding of when attenuation occurs in travelling waves and can be categorised as path loss and free space loss; 10.8.5 investigate how the Doppler Effect causes perceived frequency changes and how this can be used to calculate the relative motion of an object; and 10.8.6 interpret frequency graphs to make predictions based on the Doppler Effect.

3.11 Unit A2 5: Genetics, Stem Cell Research and Cloning

In this unit students learn about the make-up of deoxyribonucleic acid (DNA) and how evidence for its structure was determined. They have the opportunity to discuss DNA replication and how it links to genetic engineering and gene therapy.

They can also evaluate the social, ethical and economic implications of genetic engineering and relate these to modern day uses of genetics in the form of genetic fingerprinting and stem cell technology.

This unit is assessed through an external examination consisting of a series of compulsory structured questions, some of which may allow opportunities for calculation and extended writing.

Content	Learning Outcomes
11.1 DNA and the genetic code	Students should be able to: 11.1.1 recall that DNA is an information-carrying molecule and that its sequence of bases determines the structure of proteins, including enzymes; 11.1.2 describe the double helix structure of DNA, which enables it to act as a stable information-carrying molecule, in terms of: • the components of DNA nucleotides – deoxyribose, phosphate and the bases adenine, cytosine, guanine and thymine; • two sugar-phosphate backbones held together by hydrogen bonds between base pairs; and • specific base pairing; 11.1.3 provide evidence for the structure of DNA via: • chemical analysis; • Chargaff's work on base equivalence; and • Franklin and Wilkins' work on X-ray crystallography; 11.1.4 describe and explain the structure of ribonucleic acid (RNA), including ribosomal, transfer and messenger RNA; 11.1.5 describe genes and polypeptides; and 11.1.6 explain how a gene occupies a fixed position, called a locus, on a particular strand of DNA.

Content	Learning Outcomes
11.1 DNA and the genetic code (cont.)	Students should be able to: 11.1.7 recall that genes are sections of DNA that contain coded information as a specific sequence of bases; 11.1.8 recall that genes code for polypeptides which determine the nature and development of organisms; 11.1.9 demonstrate an understanding of how the base sequence of a gene can change as a result of a mutation, producing one or more alleles of the same gene; 11.1.10 recall that a sequence of three bases, called a triplet, codes for a specific amino acid; 11.1.11 demonstrate an understanding that the base sequence of a gene determines the amino acid sequence in a polypeptide; 11.1.12 explain genotype as the genetic constitution of an organism; 11.1.13 explain phenotype as the expression of this genetic constitution and its interaction with the environment; 11.1.14 demonstrate an understanding of and describe how alleles may be dominant, recessive or codominant; 11.1.15 show, for a diploid organism, that alleles at a specific locus may be either homozygous or heterozygous; 11.1.16 use fully labelled genetic diagrams to interpret, or predict, the results of: • monohybrid and dihybrid crosses involving dominant, recessive and codominant alleles; and • crosses involving sex linkage, autosomal linkage, multiple alleles and epistasis; and 11.1.17 make use of the chi-squared test to compare the goodness of fit of observed phenotypic ratios with expected ratios.

Content	Learning Outcomes
11.2 Process of DNA replication	Students should be able to: 11.2.1 describe a mechanism for the exact copying or replication of DNA; 11.2.2 explain briefly the three theories of replication of DNA that existed: • fragmentation; • conservative; and • semi-conservative; 11.2.3 explain in detail the semi-conservative hypothesis derived by Meselson and Stahl in 1958, including: • the unwinding of the double helix; • the breakage of hydrogen bonds between complementary bases in the polynucleotide strands; • the role of DNA helicase in unwinding DNA and breaking its hydrogen bonds; • the attraction of new DNA nucleotides to exposed bases on template strands and base pairing; • the role of DNA polymerase in the condensation reaction that joins adjacent nucleotides; and • comparison with the dispersive and conservative model; and
11.3 Meiosis	11.3.1 demonstrate an understanding of the importance of meiosis in producing cells that are genetically different, including: • the formation of haploid cells; • independent segregation of homologous chromosomes; • that gametes are genetically different as a result of different combinations of maternal and paternal chromosomes; and • genetic recombination by crossing over.

Content	Learning Outcomes
11.4 **The application of genetic engineering** Insulin	Students should be able to: 11.4.1 demonstrate an understanding of the fact that human insulin is a protein made in the pancreas; 11.4.2 demonstrate an understanding of how insulin is involved in the regulation of blood sugar levels but in diabetes mellitus there is a deficiency; 11.4.3 recall that insulin is extracted from natural sources such as cattle, dogs and pigs but that this insulin is not identical to human insulin and extraction of the hormone is very difficult; 11.4.4 describe how insulin can be obtained from bacteria or yeast and recall that Humulin is a licensed drug made from genetically modified E. Coli bacteria; 11.4.5 discuss the advantages of using insulin from genetically modified organisms, including: • fewer adverse reactions; • larger quantities being made; • low production costs; and • fewer ethical or religious issues, such as objections to using animals;
Factor VIII	11.4.6 discuss how haemophiliacs suffer from a defective gene that fails to produce factor VIII or IX, which is an important agent in blood clotting; and 11.4.7 recall that factor VIII was obtained from natural sources such as blood serum but this posed other major risks such as viruses, which previously resulted in many haemophiliacs contracting HIV/AIDS.

Content	Learning Outcomes
11.5 **Social, ethical and economic implications of genetic engineering**	Students should be able to: 11.5.1 evaluate and compare genetic engineering and traditional breeding in animals; 11.5.2 explain the impact of genetic engineering, with reference to: • exponential world population growth; • the amount of available land; • its potential to increase yields; and • its potential to make therapeutic chemicals in other animals, for example human serum albumin to treat burns; 11.5.3 discuss ethical issues relating to genetically modified or transgenic organisms;
11.6 **Gene therapy**	11.6.1 explain what gene therapy is; 11.6.2 discuss initial attempts at gene therapy, including attempts to treat cystic fibrosis in humans; 11.6.3 explain the cause and symptoms of cystic fibrosis and the associated gene therapy treatment; 11.6.4 describe the making of a cheese, such as Cheddar, using rennet (rennin/rennilase); 11.6.5 discuss alternative sources of protease enzyme for coagulating milk, including: • fungi such as *Rhizomucor miehei*; and • genetically modified microbes such as E. Coli or food yeasts; and 11.6.6 discuss the advantages and disadvantages of chymosin as an alternative to rennet.

Content	Learning Outcomes
11.7 Treatment of genetic conditions via gene therapy	Students should be able to: 11.7.1 discuss treating a genetic disease by altering an individual's natural genotype by: • germ cell therapy of sperm, egg or early embryo; and • somatic cell therapy; 11.7.2 recall that gene therapy can work in three ways: • by repairing the defective gene; • by replacing the faulty gene with a normal one; and • by adding a normal gene, leaving the defective one in position; 11.7.3 explain the use of gene therapy to supplement defective genes; 11.7.4 predict the probability of offspring with a particular genotype using a Punnett Square Diagram; 11.7.5 demonstrate an understanding that many human diseases result from mutated genes or from genes that are useful in one context but not in another, for example sickle cell anaemia and aneuploidy; 11.7.6 recall that DNA sequencing and the polymerase chain reaction (PCR) are used to produce DNA probes that can screen patients for clinically important genes; and 11.7.7 recall that this information is used in genetic counselling, for example: • in family planning for parents who are both carriers of defective genes; and • in the case of oncogenes, in deciding the best course of treatment for cancers.

Content	Learning Outcomes
11.8 Gene cloning	Students should be able to: 11.8.1 discuss gene cloning technologies that allow for the study and alteration of gene function in order to: • understand organism function better; and • design new industrial and medical processes; 11.8.2 evaluate the ethical, moral and social issues associated with the use of recombinant technology in agriculture, in industry and in medicine; 11.8.3 discuss the humanitarian aspects of recombinant DNA technology and the opposition from environmentalists and anti-globalisation activists;
11.9 Genetic fingerprinting	11.9.1 demonstrate an understanding that an organism's genome contains many repetitive, non-coding base sequences and that the probability of two individuals having the same repetitive sequences is very low; 11.9.2 evaluate the technique of genetic fingerprinting (using bars on DNA fingerprints) in analysing DNA fragments that have been cloned by PCR; 11.9.3 evaluate the use of genetic fingerprinting in determining genetic relationships and the genetic variability within a population; 11.9.4 explain the biological principles that underpin genetic fingerprinting techniques; 11.9.5 interpret data showing the results of gel electrophoresis to separate DNA fragments; and 11.9.6 explain why scientists might use genetic fingerprints in the fields of forensic science, medical diagnosis, and animal and plant breeding.

Content	Learning Outcomes
11.10 Stem cell technology	Students should be able to: 11.10.1 discuss what stem cells are and why they are important; 11.10.2 explain the unique properties of stem cells; 11.10.3 explain how stem cells differ from all other cells; 11.10.4 describe what embryonic stem cells are and how embryonic stem cells are stimulated to differentiate; 11.10.5 describe what adult stem cells are, where they are found and what they normally do; 11.10.6 explain the similarities and differences between embryonic and adult stem cells; and 11.10.7 evaluate and discuss the ethical issues raised through the use of stem cell technology.

3.12 Unit A2 6: Microbiology

In this unit students cover the theory and practical techniques that provide a fundamental understanding of microbiology. In the context of life science and medical applications in health, students learn practical techniques in the study of microorganisms and microscopy; health and safety protocols for working with biological agents; the control conditions for quality assured investigation; aseptic techniques; growth media; inoculation; incubation; inhibition; and measurement of microbial growth factors. Students also explore modern application of microorganisms in academic research, commercial industry and interdisciplinary STEM innovations.

This unit is internally assessed; students complete a portfolio of evidence. They present this evidence as reports and a lab book, demonstrating how they have achieved all the learning outcomes.

Content	Learning Outcomes
12.1 Record keeping and formal written communication for microbiological study	Students should be able to: 12.1.1 produce reports of the practical work defined for assessment in their portfolio: • write up their investigations in accordance with the standard laboratory practical report guidelines for microbiology; • apply the Harvard referencing protocol; • describe and apply health, safety and environmental methodology to modern standards, in line with current legislation; and • describe and apply quality assurance methodology to modern standards; 12.1.2 maintain a lab book as a record of work, taking health, safety and quality into account; and
12.2 Microorganisms	12.2.1 identify and describe the characteristic features, functions and means of reproduction or replication of microorganisms and infectious agents: • bacteria; • fungi, including yeasts; • protozoa; • viruses; • viroids; and • prions.

Content	Learning Outcomes
12.2 Microorganisms (cont.)	Students should be able to: 12.2.2 classify bacteria, including reference to Bergey's Manual: • using Gram staining; • according to phenotypic classification, for example cocci, bacilli and spirilla; and • according to oxygen requirements (obligate and facultative aerobes or anaerobes); 12.2.3 classify fungi as: • chytridiomycota; • zygomycota; • ascomycota; and • basidiomycota; 12.2.4 classify viruses according to their: • size; • nucleic acid; • capsid structure; • host; and • disease;
12.3 Microscopy	12.3.1 describe the basic principles of light microscopy: • oil immersion; and • phase contrast, including the use of lenses to convert the differences between transmitted and refracted light into variations in intensity; 12.3.2 define image, focus, magnification and resolution; 12.3.3 explain the basic principles of electron microscopy: • scanning; and • transmission; and 12.3.4 compare the use of the light microscope with that of the electron microscope: • describe the suitability and preparation of samples for use in each case; and • give advantages and disadvantages of each technique.

Content	Learning Outcomes
12.4 Microscopy techniques	Students should be able to: 12.4.1 carry out microscopy for specimen examination in the laboratory, including: • preparing specimens and slides; and • setting up and using a compound light microscope;
12.5 Safety controls, prevention of contamination and aseptic techniques	12.5.1 describe safety controls and prevention of contamination: • biocontainment (positive: protect the sample and negative: protect the operator or environment); • laminar flow; • clean air cabinets; and • safe disposal methods;
12.6 Growth media, inoculation and incubation	12.6.1 culture microorganisms using aseptic techniques, including: • disinfection and sterilisation techniques in preparing sterile growth media; • inoculation of liquid media; • inoculation of solid media, for example pour plates, streak plates, lawn plates, mycelial discs, fungal spore inoculation and viral plaque counts (lysis on solid media or lysis in liquid media using a colorimeter); and • haemocytometer counts; and
12.7 Measurement techniques	12.7.1 demonstrate measurement techniques, including: • serial dilutions; • viable counts; • total counts; • microbiological assays; • dry mass determination; • growth of mycelial discs; • viral plaque counts (liquid or solid media); and • using colorimetry to determine turbidity in liquid media.

Content	Learning Outcomes
12.8 Requirements, inhibitors and measurement of microbial growth factors	Students should be able to: 12.8.1 describe growth requirements of bacteria and fungi: • nutrients; • aerobic and anaerobic conditions; • temperature; • light; • pH; and • growth surfaces; 12.8.2 describe methods of growth inhibition with reference to their application: • osmotic potential; • irradiation; • antibiotics; • antifungals; • antivirals; • disinfection; and • sterilisation; and 12.8.3 compare the theory and practical application of growth monitoring techniques, including interpretation of resulting data: • counting bacterial colonies; • mycelial discs (measured as increase in diameter or dry mass); • colorimetry for fungal, bacterial and viral growth showing turbidity; and • haemocytometer (in yeast cell counts).

Content	Learning Outcomes
12.9 Applications of microorganisms	Students should be able to: 12.9.1 investigate and report on contemporary academic research, commercial industry and interdisciplinary STEM innovations in the applications of microorganisms: • functions of microorganisms in human body systems; • the production of antibiotics, resistance to antibiotics and future challenges; • human gene therapy; • polymerase chain reaction (PCR) assays; • infectious diseases; and • pharmaceutical microbiology; and
12.10 Microbiology and human health	12.10.1 explain the role of gut microbiota in health and disease: • a healthy gut microbiome; • methods for studying the gut microbiome, for example high-throughput sequencing (HTS) technologies and nongenomic techniques; • gastrointestinal (GI) disease; • current research relating the gut to other health problems, for example poor diet and nutrition, obesity, inflammatory bowel disease (IBD) and cancer; and • faecal microbiota transplant.

3.13 Unit A2 7: Oral Health and Dentistry

Good oral health is central to general well-being. This unit gives students the opportunity to learn about the structure and function of the mouth and its component parts. Good oral health is underpinned by effective dental hygiene and supported by the work of dental healthcare professionals in preventing, treating and rectifying dental problems, such as tooth loss. In this unit students learn how dental caries and periodontal disease can develop and how these are treated. They also consider the impact of tooth loss as a result of these diseases. They learn about the roles of key dental healthcare professionals and about the application and function of materials used in dentistry.

This unit is internally assessed; students complete a portfolio of evidence. They present this evidence as reports (general and practical, as appropriate). They must keep a portfolio record sheet demonstrating how they have achieved all the learning outcomes.

Content	Learning Outcomes
13.1 Structure and function of the mouth	Students should be able to: 13.1.1 identify and describe the structure and function of the mouth and its main components, including the vestibule, oral cavity proper, teeth, lips, alveolar process, isthmus of the fauces, hard palate, soft palate, mylohyoid muscles, tongue and taste buds; 13.1.2 describe the five basic tastes of saltiness, sourness, bitterness, sweetness and umami; 13.1.3 explain what the detection of basic tastes may indicate, including that: • saltiness and sourness are involved in the control of salt and acid balance; • bitterness may indicate plant-based poisons; • sweetness indicates energy-rich foods; • umami may indicate protein-rich food; and • sour tastes may indicate rotten or decomposing food; and 13.1.4 compare the structure and function of the three pairs of main salivary glands (parotid, submaxillary and sublingual).

Content	Learning Outcomes
13.1 Structure and function of the mouth (cont.) **13.2 Ingestion**	Students should be able to: 13.1.5 explain the importance of the salivary glands for the digestive process, the maintenance of dental health and lubrication of the mouth; 13.1.6 describe the chemical composition of teeth; 13.2.1 explain the importance of the mouth as the first part of the gastrointestinal tract; 13.2.2 explain ingestion as part of the human digestive system where the actions of teeth (mastication), saliva and mucus produce a soft food bolus which is swallowed and passes via the upper gastrointestinal tract to the stomach; 13.2.3 explain physical digestion in terms of teeth and mastication; 13.2.4 identify and state the function of the teeth: • incisors; • canines; • premolars; and • molars; and 13.2.5 investigate practically the role of salivary glands and other oral glands, including their role in chemical and microbiotic digestion: • the production of enzymes, for example amylase, begins the breakdown of starch in carbohydrates into maltose and dextrose, and lipase begins the process of fat digestion; • saliva contains haptocorrin, which binds to vitamin B12 molecules to protect these from damage by stomach acid; and • inorganic nitrate obtained from the diet (for example green leafy vegetables) and transported to the salivary glands is reduced by oral bacteria to produce nitrite.

Content	Learning Outcomes
13.3 Prevention and treatment of oral disease	Students should be able to: 13.3.1 describe how dental caries develop and how they can be treated and prevented; 13.3.2 investigate practically the antimicrobial properties of a range of different toothpastes and mouthwashes; 13.3.3 explain how periodontal disease develops and how it can be treated and prevented; 13.3.4 predict the impact of dental disease and tooth loss on general health; 13.3.5 investigate practically how acid erosion of teeth can be accelerated by diseases, for example bulimia or gastro-oesophageal reflux disease; 13.3.6 compare and contrast the use of the dental antibiotics Clindamycin, Cephalexin and Amoxicillin;
13.4 Dental material science	13.4.1 investigate the main materials used in dentistry and evaluate how the properties of dental materials relate to their application and function; 13.4.2 compare through practical investigation the main fixed and removable prosthodontics used in dentistry, the dental materials used in their construction and the processes used to retain prosthodontics in the oral cavity;
13.5 Roles of dental healthcare professionals	13.5.1 demonstrate an understanding of the roles of dental healthcare professionals, including the dentist, dental hygienist, dental technician, dental therapist and dental nurse; and 13.5.2 produce a case study of the qualifications, competences and skills required by a dentist, dental hygienist, dental technician, dental therapist and dental nurse.

3.14 Unit A2 8: Histology and Pathology

Pathology services are generally located in hospitals and provide diagnostic services to medical staff working within both general practices (GP) and hospitals. They involve a number of departments, including clinical biochemistry, microbiology, haematology and histopathology. In this unit students explore how each of these departments operates and how analysing patient samples can provide doctors with information they need to diagnose diseases. Students learn about types of samples that are analysed or investigated, how these samples are tracked and how results are reported. The unit also considers the importance of health and safety practices.

This unit is internally assessed; students complete a portfolio of evidence. They present this evidence as reports (general and practical, as appropriate). They must keep a portfolio record sheet demonstrating how they have achieved all the learning outcomes.

Content	Learning Outcomes
14.1 Specimen processing and legislation	Students should be able to: 14.1.1 undertake practical activities to understand the stages involved in processing specimens in each pathology department, including: • the sending and receipt of specimens; • recording, sorting and storage; • testing; and • noting, interpretation and dissemination of results, taking the use of computers and the Data Protection Act 1998 into account; 14.1.2 demonstrate an understanding of the role of legislation in maintaining health and safety in each pathology department;
14.2 Biochemistry department	14.2.1 demonstrate an understanding of the role of the biochemistry department and the types of specimens tested; and 14.2.2 investigate and demonstrate an understanding of common types of tests performed, for example: • testing for glucose in blood and urine; • testing for sodium and potassium in blood; and • estimating blood cholesterol.

Content	Learning Outcomes
14.2 Biochemistry department (cont.)	Students should be able to: 14.2.3 demonstrate an understanding that the results of analytical chemical tests taken in the biochemistry department: • aid the diagnosis of disease in patients; and • may provide information to support doctors in patient treatment; 14.2.4 demonstrate, through practical investigation, an understanding of the principles involved in either thin layer chromatography or electrophoresis, using these principles to conduct either a chromatographic or an electrophoretic analysis; 14.2.5 demonstrate an understanding of the importance of health and safety principles in relation to: • the testing of glucose in blood and urine; • the testing of sodium and potassium in blood; • the estimation of blood cholesterol; and • thin layer chromatography or electrophoresis; 14.2.6 demonstrate an understanding of the knowledge and skills used by those working in the biochemistry department and link this directly to their chromatographic or electrophoresis analysis;
14.3 Haematology department	14.3.1 know the role of the haematology department and types of specimens tested; and 14.3.2 demonstrate an understanding that tests taken in the haematology department relate to blood analysis, for example: • the diagnosis of blood-related diseases such as leukaemia; and • cross-matching of blood for surgical patients.

Content	Learning Outcomes
14.3 Haematology department (cont.)	Students should be able to: 14.3.3 demonstrate, through practical investigation, an understanding of the nature of work undertaken in the department, including: • the preparation of blood smears; and • the identification of various types of cells such as red blood cells, neutrophils, eosinophils and platelets; 14.3.4 demonstrate an understanding of the importance of health and safety principles in relation to handling blood and blood products;
14.4 Microbiology department	14.4.1 know the role of the microbiology department and the types of specimens tested; 14.4.2 demonstrate an understanding that the microbiology department: • monitors infectious diseases (bacterial, viral, fungal and parasitic) in hospitals and the community; • provides a diagnostic service to primary healthcare workers; and • monitors community microbial diseases, undertaking antibiotic assays and cross-infection surveys and monitoring antibiotic resistance; 14.4.3 demonstrate an understanding of the nature of work undertaken in the department, including: • the Gram's staining technique to distinguish between Gram-positive and Gram-negative bacteria; and • investigating the effectiveness of antiseptics and antibiotics on microbes using the dilution plate technique and the enzyme-linked immunosorbent assay (ELISA) technique; and 14.4.4 demonstrate an understanding of the importance of health and safety principles in relation to the tests carried out.

Content	Learning Outcomes
14.4 Microbiology department (cont.)	Students should be able to: 14.4.5 demonstrate an understanding of the knowledge and skills used by those working in the microbiology department and link this directly to their own microbiological analysis;
14.5 Histopathology department	14.5.1 demonstrate an understanding of the role of the histopathology department and the type of specimens tested; 14.5.2 demonstrate an understanding that: • assays undertaken in tissue biopsies, or from tissue removed during surgery, help to diagnose diseases; and • analysing tissue from deceased persons may help to identify causes of death; 14.5.3 know the nature of the work undertaken in the department, including the identification of various types of cells such as blood, heart, muscle, artery, vein, kidney and liver; 14.5.4 demonstrate an understanding of how to prepare tissue samples for microscope slides and how to recognise atheroma and emphysema from prepared microscope slides; and 14.5.5 demonstrate an understanding of the importance of health and safety principles in relation to the tests carried out.

3.15 Unit A2 9: Analytical Chemistry Techniques

In this unit students develop skills in performing a range of analytical chemical techniques used in many chemical industries, including volumetric analysis, chromatography and colorimetry.

This unit is internally assessed; students complete a portfolio of evidence. They present this evidence as reports (general and practical, as appropriate). They must keep a portfolio record sheet demonstrating how they have achieved all the learning outcomes.

Content	Learning Outcomes
15.1 Volumetric analysis	Students should be able to: 15.1.1 describe volumetric analysis using key scientific terminology as an accurate method to determine the amount of a substance present in a sample; 15.1.2 describe at least three situations in which a chemist would carry out a titration; 15.1.3 prepare a standard solution using a standard procedure; 15.1.4 describe and carry out **one** titration set in an applied context, for example finding: • the concentration of ethanoic acid in different vinegars; • the amount of iron in different iron tablets; • the effectiveness of different indigestion tablets; or • the concentration of different bleaches; 15.1.5 carry out a risk assessment; 15.1.6 construct a balanced symbol equation for the reaction involved in the selected titration; 15.1.7 use the balanced symbol equation and results from the titration to carry out relevant calculations; 15.1.8 analyse and interpret the results from the selected titration and report on the accuracy and reliability of their procedure; and 15.1.9 suggest alternatives or improvements to the method they used.

Content	Learning Outcomes
15.2 Colorimetry	Students should be able to: 15.2.1 describe colorimetry using key scientific terminology as an accurate method to determine the concentration of a substance present in a sample; 15.2.2 describe at least three situations in which a chemist would use colorimetry; 15.2.3 describe the procedure and prepare a series of solutions accurately to produce a calibration curve; 15.2.4 describe and carry out **one** colorimetric analysis set in an applied context, for example finding: • the concentration of copper in copper ore; • the concentration of aspirin in different aspirin tablets; or • the concentration of iron in aluminium foil; 15.2.5 carry out a risk assessment; 15.2.6 construct a balanced symbol equation for the reaction involved in the selected colorimetric analysis; 15.2.7 construct a calibration curve and use it to determine the concentration of the selected substance; 15.2.8 analyse and interpret the results from the colorimeter and report on the accuracy and reliability of their procedure; and 15.2.9 suggest alternatives or improvements to the method they used.

Content	Learning Outcomes
15.3 Chromatography	Students should be able to: 15.3.1 describe chromatography using key scientific terminology as an accurate method to determine the identity of a substance present in a sample; 15.3.2 describe at least three situations in which a chemist would use chromatography; 15.3.3 describe the procedure and prepare a chromatography plate accurately; 15.3.4 describe and carry out **one** chromatography experiment set in an applied context, for example identifying: • the components of different painkillers; • amino acids in a mixture; or • the pigments in different leaves; 15.3.5 carry out a risk assessment; 15.3.6 describe the visualisation of chromatograms, for example ninhydrin and UV visualisation; 15.3.7 use the experimental results to calculate R_f values; and 15.3.8 suggest alternatives or improvements to the method they used.

Content	Learning Outcomes
15.4 Calorimetry	Students should be able to: 15.4.1 describe calorimetry using key scientific terminology as an accurate method to determine the enthalpy change during a reaction (usually combustion); 15.4.2 describe at least three situations in which a chemist would use calorimetry; 15.4.3 describe the importance of combustion reactions in an everyday context; 15.4.4 describe the different types of calorimeter and the procedure of using a simple calorimeter; 15.4.5 describe and carry out **one** calorimetry experiment set in an applied context, for example comparing: • the energy released when burning different alcohols; or • the energy released when burning different foods; 15.4.6 carry out a risk assessment; 15.4.7 use the experimental results to calculate the molar enthalpy change of the reactions involved; 15.4.8 carry out bond energy calculations to compare theoretical results with their actual results; 15.4.9 account for any discrepancies between actual and theoretical results; and 15.4.10 suggest alternatives or improvements to the method they used.

Content	Learning Outcomes
15.5 Qualitative analysis	Students should be able to: 15.5.1 describe qualitative analysis using key scientific terminology as a method to determine the identity of an unknown compound; 15.5.2 describe at least three situations in which a chemist would use qualitative analysis; 15.5.3 describe the procedure for, and carry out, standard identification tests including: • flame tests to identify metal ions; • precipitation reactions with sodium hydroxide; • precipitation reactions with ammonia solution; • tests for common gases – hydrogen, oxygen, carbon dioxide and ammonia; and • tests for anions – sulfate, carbonate, nitrate and halides; 15.5.4 carry out a risk assessment for each identification test; 15.5.5 construct word and balanced symbol equations to describe these tests; 15.5.6 plan and carry out a series of tests to identify an unknown compound set in an applied context, for example: • identifying a water pollutant; and • identifying an unknown powder found at a crime scene; 15.5.7 describe the limitations of these tests; and 15.5.8 suggest alternatives or improvements to the method they used, including reference to modern instrumentation.

3.16 Unit A2 10: Enabling Technology

In this unit students research and discuss modern medical equipment and how it improves on prior equipment and methodologies. They explore the work that is done in a medical laboratory. Students conduct a case study of a patient (either real or hypothetical) who requires ongoing medical monitoring. They end the unit by creating a database for ongoing health monitoring and consider the implications of holding such data.

This unit is internally assessed; students complete a portfolio of evidence. They present this evidence in various forms including case studies, databases, investigations, reports and fact sheets to demonstrate how they have achieved all the learning outcomes.

Content	Learning Outcomes
16.1 Equipment used in modern medicine	Students should be able to: 16.1.1 identify equipment used in: • patient monitoring (for example electrocardiogram (ECG) and electroencephalogram (EEG) machines); • fertility (for example ultrasound scanner, in vitro fertilisation (IVF) egg collection and fertilisation equipment); • medical laboratory (for example colorimeter and chromatograph); and • prosthetics (for example artificial limbs and hearing aids); 16.1.2 describe how these pieces of equipment have improved the monitoring, decision-making, workflow and/or patient outcomes; 16.1.3 explain the purpose of the equipment; 16.1.4 choose one piece of equipment and describe any previous methodologies or equipment that it has replaced; and 16.1.5 provide a clear description of how the equipment works.

Content	Learning Outcomes
16.2 Workflow in a medical laboratory	Students should be able to: 16.2.1 describe three tests performed in a medical laboratory, including: • the nature of each test; and • the work procedure that occurs from request to return of information; 16.2.2 identify the staff involved in the three tests chosen in 16.2.1; 16.2.3 describe any specialist equipment involved in the tests chosen in 16.2.1; and
16.3 Medical monitoring case study	16.3.1 carry out a case study of a patient (real or hypothetical) who has a medical condition that requires ongoing use of medical monitoring equipment, including: • a statement of the name, gender, age, occupation and any other information that may be of medical note about the individual (either real or hypothetical); • a description of the medical condition they are suffering from, its effects on the individual (biologically and on quality of life) and long-term prognosis; • a clear discussion about the nature of the medical equipment used and how it works (both mechanically and when operated by the user); and • how the information gathered is reviewed and potentially used.

Content	Learning Outcomes
16.4 Data collection and filtering	Students should be able to: 16.4.1 collect medical information from a group of individuals (at least five), including their: • name; • age; • gender; • pre-existing medical conditions; • resting pulse rate (pre- and post-intervention); • mass (pre- and post-intervention); • height; • body mass index (BMI); • blood pressure; • body temperature; and • peak expiratory flow; 16.4.2 develop a simple, moderate exercise regime to be followed by each individual which is appropriate for them; 16.4.3 collect and record quantitative information obtained about the exercise via technology (for example steps taken using a pedometer, distance run using a Global Positioning System (GPS) watch or smartphone, and calories burned) and any other suitable measurable data; 16.4.4 build a database of the collected medical information; 16.4.5 update the database regularly over a period of six weeks to assess the health effects of moderately increased exercise; 16.4.6 build into the database sufficient fields to allow for storage of old data (so it is possible to search for body temperature on Week 1 as well as Week 2, and so on); and 16.4.7 query the database to filter and extract information about particular patients or groups of patients of the same type (for example of the same age or same pre-existing medical conditions).

Content	Learning Outcomes
16.4 Data collection and filtering (cont.)	Students should be able to: 16.4.8 compare information from the same patient and across multiple patients; and 16.4.9 discuss the benefits and dangers of holding large amounts of health data on the population as a whole.

4 Scheme of Assessment

4.1 Assessment opportunities

Each unit is available for assessment in summer each year. It is possible to resit individual AS and A2 assessment units once and count the better result for each unit towards an AS or A level qualification. Candidates' results for individual assessment units can count towards a qualification until we withdraw the specification.

4.2 Assessment objectives

There are three assessment objectives for this specification. Candidates must:

- demonstrate knowledge and understanding of scientific ideas, processes, techniques, and procedures (AO1);
- apply knowledge and understanding of scientific ideas, processes, techniques and procedures:
  - in a range of theoretical and practical contexts; and
  - when handling qualitative and quantitative data, to solve scientific problems (AO2); and
- analyse, interpret and evaluate a range of scientific information, ideas and evidence to:
  - make judgements and reach conclusions (including in relation to issues); and
  - refine practical design and procedures (AO3).

4.3 Assessment objective weightings

The tables below set out the assessment objective weightings for the overall AS and A level qualifications.

Single Award

Percentage Assessment Objective Weightings					
	AO1	**AO2**	**AO3**	**AS**	**A level**
Unit AS 1	2.0	2.5	8.9	13.4	13.4
Unit AS 2	6.0	4.4	2.9	13.3	13.3
Unit AS 3	5.9	4.4	3.0	13.3	13.3
Unit A2 1	3.0	3.7	13.3		20
Unit A2 2	9.2	6.4	4.4		20
Optional unit: A2 3, A2 4 or A2 5	9.0	6.6	4.4		20
Totals	35.1	28.0	36.9	40	100
A tolerance of +/–3% is applicable to the weightings above.					

Double Award

Percentage Assessment Objective Weightings						
		AO1	**AO2**	**AO3**	**AS**	**A level**
Unit AS 1		1.0	1.2	4.5	6.7	6.7
Unit AS 2		3.0	2.2	1.5	6.7	6.7
Unit AS 3		2.9	2.2	1.5	6.6	6.6
Unit AS 4		1.0	1.2	4.4	6.6	6.6
Unit AS 5		3.1	1.9	1.7	6.7	6.7
Unit AS 6		1.0	1.2	4.5	6.7	6.7
Unit A2 1		1.5	1.9	6.6		10.0
Unit A2 2		4.6	3.2	2.2		10.0
Two units chosen from A2 3, A2 4 and A2 5	**First unit**	4.5	3.3	2.2		10.0
	Second unit	4.5	3.3	2.2		10.0
Two units chosen from A2 6, A2 7, A2 8, A2 9 and A2 10	**First unit**	1.5	1.8	6.7		10.0
	Second unit	1.5	1.8	6.7		10.0
Totals		**30.1**	**25.2**	**44.7**		**100**
A tolerance of +/–3% is applicable to the weightings above.						

4.4 Quality of written communication

In AS and A level Life and Health Sciences, candidates must demonstrate their quality of written communication. They need to:

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

Quality of written communication is assessed in responses to questions and tasks that require extended writing.

4.5 Synoptic assessment at A2

The A2 assessment units include some synoptic assessment, which encourages candidates to develop their understanding of the subject as a whole. In our GCE Life and Health Sciences, synoptic assessment involves:

- building on material from the AS units;
- bringing together and making connections between areas of knowledge and skills that they have explored throughout the course;
- applying knowledge and understanding of more than one area to a particular situation or context; and
- continuing to use fundamental concepts and mathematical skills developed at AS level.

4.6 Higher order thinking skills

The A2 assessment units provide opportunities to demonstrate higher order thinking skills by incorporating:

- questions that are less structured;
- a wider range of question types to address different skills, including planning, manipulative skills, data analysis, and interpreting and evaluating results in the practical assessments;
- more demanding evaluative opportunities involving novel and current developments in life and health sciences that require candidates to apply their knowledge to unfamiliar situations;
- questions that require candidates to make more connections between all of the sections of the specification, including AS; and
- extended writing.

4.7 Reporting and grading

We offer four different awards with units common to each.

Candidates entering for the three unit AS (Single Award) must take units **AS 1**, **AS 2** and **AS 3**, and those taking the six unit AS (Double Award) must take **all six** available AS units.

Candidates taking the six unit GCE (Single Award) must take units **AS 1**, **AS 2** and **AS 3**, the compulsory A2 units (**A2 1** and **A2 2**) and **one** other A2 unit (A2 3, A2 4 or A2 5).

Candidates taking the 12 unit GCE (Double Award) must take **all six** available AS units, the compulsory A2 units (**A2 1** and **A2 2**), **two** other A2 units with external examination (A2 3, A2 4 and/or A2 5) and **two** other A2 units with internal assessment (A2 6, A2 7, A2 8, A2 9 and/or A2 10).

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

We award AS Single Award qualifications on a five grade scale from A to E, with A being the highest. We award A level Single Award qualifications on a six grade scale from A* to E, with A* being the highest.

We award AS Double Award qualifications on a nine grade scale from AA to EE, with AA being the highest. We award A level Double Award qualifications on an eleven grade scale from A*A* to EE, with A*A* being the highest.

We award AS and A level grades by aggregating the uniform marks obtained on individual assessment units. To be awarded an A*, candidates need to achieve a grade A on their full A level qualification and at least 90 percent of the maximum uniform marks available for the A2 units. If candidates fail to attain a grade E or EE, we report their results as unclassified (U or UU).

The grades we award match the grade descriptions in Section 5 of this specification.

5 Grade Descriptions

Grade descriptions are provided to give a general indication of the standards of achievement likely to have been shown by candidates awarded particular grades. The descriptions must be interpreted in relation to the content in the specification; they are not designed to define that content. The grade awarded depends in practice upon the extent to which the candidate has met the assessment objectives overall. Shortcomings in some aspects of candidates' performance in the assessment may be balanced by better performances in others.

AS Grade Descriptions

Grade	Description
AS **Grade A**	For AO1, candidates characteristically: • demonstrate knowledge and understanding of most principles, concepts and facts from the AS units; • select relevant information from the AS units; and • organise and present information clearly in appropriate forms using scientific terminology. For AO2, candidates characteristically: • apply biological, chemical and physical principles and concepts in familiar and new contexts; • apply skills, knowledge and understanding of processes, techniques and equipment; • demonstrate safe and skilful practical techniques; • make observations with appropriate precision and record these methodically; • describe significant trends and patterns shown by data presented in tabular or graphical form; • explain and interpret phenomena with few errors and present arguments and evaluations clearly; • comment critically on statements, conclusions or data; • carry out most structured calculations specified for AS accurately; • use a range of chemical equations; and • translate data presented as prose, diagrams, drawings, tables or graphs successfully from one form to another.

Grade	Description
AS **Grade A (cont.)**	For AO3, candidates characteristically: • analyse and offer a valid evaluation of scientific information, issues and viewpoints; • devise and refine experimental and investigative activities, selecting appropriate techniques; • demonstrate safe and skilful practical techniques; • make observations and measurements with appropriate precision and record these methodically; • interpret, explain, evaluate and communicate the results of their own and others' experimental and investigative activities, in appropriate contexts; and • reach valid conclusions and communicate findings clearly and in a structured manner appropriate to the task.
AS **Grade E**	For AO1, candidates characteristically: • demonstrate knowledge and understanding of some principles, concepts and facts from the AS units; • select some relevant information from the AS units; and • present information using basic terminology from the AS units. For AO2, candidates characteristically: • apply given biological, chemical and physical principles and concepts in familiar and new contexts; • apply some skills, knowledge and understanding of processes, techniques and equipment; • demonstrate safe practical techniques; • make and record observations and measurements; • describe some trends and patterns shown by data presented in tabular or graphical form; • provide basic explanations and interpretations of some phenomena, presenting very limited evaluations; • comment critically on statements, conclusions or data; • carry out some steps within calculations; • use simple chemical equations; and • translate data presented from one form to another, in some contexts.

Grade	Description
AS **Grade E (cont.)**	For AO3, candidates characteristically: • offer some limited evaluation of scientific information, issues and viewpoints; • devise and plan some aspects of experimental and investigative activities; • demonstrate safe practical techniques; • make and record observations and measurements; • interpret, explain and communicate some aspects of the results of their own and others' experimental and investigative activities, in appropriate contexts; and • draw some limited conclusions and communicate findings.

A2 Grade Descriptions

Grade	Description
A2 **Grade A**	For AO1, candidates characteristically: • demonstrate detailed knowledge and understanding of most principles, concepts and facts from the specification; • select relevant information from the specification; • organise and present information clearly in appropriate forms using scientific terminology; and • write equations for chemical reactions in the specification. For AO2, candidates characteristically: • apply biological, chemical and physical principles and concepts in familiar and new contexts; • apply skills, knowledge and understanding of processes, techniques and equipment; • demonstrate safe and skilful practical techniques; • make observations with appropriate precision and record these methodically; • describe significant trends and patterns shown by data presented in tabular or graphical form; • explain and interpret phenomena with few errors and present arguments and evaluations clearly; • critically evaluate statements, conclusions or data; • carry out complex calculations specified for A level accurately; • use chemical equations in a range of contexts; • translate data presented as prose, diagrams, drawings, tables or graphs from one form to another successfully; • select a wide range of facts, principles and concepts; and • link together appropriate facts, principles and concepts from different areas of the specification. For AO3, candidates characteristically: • devise and plan experimental and investigative activities, selecting appropriate techniques; • demonstrate safe and skilful practical techniques; • make observations and measurements with appropriate precision and record these methodically; and • interpret, explain, evaluate and communicate the results of their own and others' experimental and investigative activities, in appropriate contexts.

Grade	Description
A2 **Grade E**	For AO1, candidates characteristically: • demonstrate knowledge and understanding of some principles, concepts and facts from the specification; • select some relevant information from the specification; and • present information using basic terminology from the specification. For AO2, candidates characteristically: • apply given biological, chemical and physical principles and concepts in familiar and new contexts; • apply some skills, knowledge and understanding of processes, techniques and equipment; • demonstrate safe practical techniques; • make and record observations and measurements; • describe and provide a limited explanation of trends and patterns shown by complex data presented in tabular or graphical form; • identify, when directed, inconsistencies in conclusions or data; • critically evaluate statements, conclusions or data; • carry out some steps within calculations; • use some chemical equations; • successfully translate data from one form to another in some contexts; • select some facts, principles and concepts; and • put together some facts, principles and concepts from different areas of the specification. For AO3, candidates characteristically: • devise and plan some experimental and investigative activities; • demonstrate safe practical techniques; • make and record observations and measurements; and • interpret, explain and communicate some aspects of the results of their own and others' experimental and investigative activities, in appropriate contexts.

6 Guidance on External Assessment

There are seven external assessment units in this specification, three at AS level and four at A2:

- Unit AS 2: Human Body Systems;
- Unit AS 3: Aspects of Physical Chemistry in Industrial Processes;
- Unit AS 5: Material Science;
- Unit A2 2: Organic Chemistry;
- Unit A2 3: Medical Physics;
- Unit A2 4: Sound and Light; and
- Unit A2 5: Genetics, Stem Cell Research and Cloning.

Single Award candidates take **two** external assessment units at AS level (Unit AS 2 and Unit AS 3) and **two** at A2 (including Unit A2 2).

Double Award candidates take all **three** external assessment units at AS level and **three** at A2 (including Unit A2 2).

The external assessments are 1 hour 30 minutes at AS level, with 75 marks available. They are 1 hour 45 minutes at A2, with 100 marks available.
They cover all assessment objectives. We mark the assessments.

7 Guidance on Internal Assessment

There are nine internal assessment units in this specification, three at AS level and six at A2:

- Unit AS 1: Experimental Techniques;
- Unit AS 4: Brain Science;
- Unit AS 6: Medicine, Drugs and Clinical Trials;
- Unit A2 1: Scientific Method, Investigation, Analysis and Evaluation;
- Unit A2 6: Microbiology;
- Unit A2 7: Oral Health and Dentistry;
- Unit A2 8: Histology and Pathology;
- Unit A2 9: Analytical Chemistry Techniques; and
- Unit A2 10: Enabling Technology.

Single Award candidates take **one** internal assessment unit at AS level (Unit AS 1) and **one** at A2 (Unit A2 1).

Double Award candidates take all **three** internal assessment units at AS and **three** at A2 (including Unit A2 1).

7.1 Skills assessed by internal assessment

Teachers must assess the following skills through internal assessment:

- working independently to select and interpret appropriate information;
- applying knowledge, understanding and skills to a range of contexts;
- carrying out risk assessments;
- researching, using primary and secondary sources, and analysing and presenting findings from the research undertaken;
- analysing, evaluating and drawing conclusions, making reasoned arguments; and
- writing succinctly, clearly and coherently using specialist terms with appropriate referencing.

There may also be external assessment of elements of all these skills.

7.2 Setting the tasks

We provide centres with details of the requirements of the internal assessment tasks and guidance on how to complete and submit them. (See the assessment task requirements included in this specification and with each unit, and support materials.)

7.3 Taking the tasks

Internal assessment is likely to involve both work in the classroom and independent study. It is essential to manage the assessment conditions in a way that ensures the assessment remains reliable and fair. Please note the requirements below.

Area	Assessment Conditions
Supervision	Teachers should supervise candidates' work to: • monitor their progress; • prevent plagiarism and check that the work which candidates submit is their own; • comply with health and safety requirements; • provide advice and guidance if there are any problems; and • ensure that the work aligns with the specification requirements and can be marked using the assessment criteria.
Authenticity	Teachers must be aware of any third party copyright or intellectual property issues in candidates' work. Each portfolio will require an official Statement of Authenticity. Both the candidate and the teacher must sign the form to confirm that the evidence submitted is the candidate's own unaided work. We cannot accept unauthenticated submissions and will return these to the centre unmarked.
Word Limit	The sections that follow include word limits where these apply.
Collaboration	Candidates must work independently when completing their internal assessments. Teachers should annotate work and inform the moderator of specific reasons why in some tasks, such as experiments, collaboration approaches were necessary.
Resources	Candidates must appropriately reference all the materials they use in their work, including any online resources, using the Harvard referencing system where appropriate.

The following sections include information specific to each internally assessed unit.

7.4 Unit AS 1: Experimental Techniques

Unit AS 1: Experimental Techniques	
Overview	Candidates create a portfolio of evidence that includes **12** investigations demonstrating how they have achieved the 12 learning outcomes for this unit (listed in Section 3.1). Each investigation should be set by the teacher to allow candidates access to the full range of marks available. Candidates should present each investigation as a report, using the headings provided in the candidate guidance document and pro forma. Each report should be **1000 words**. The quality of written communication is assessed. Candidates must complete the investigations using the guidance that we provide. This is available on our Life and Health Sciences microsite at www.ccea.org.uk
Submission Requirements	Candidates submit one scientific report for each investigation that they have completed. The reports should be collated to be presented and submitted as a portfolio of evidence.
Marks and Assessment	There are **240 marks** available for this unit. Each investigation is worth 20 marks: • Introduction – 2 marks • Materials and apparatus – 2 marks • Risk assessment – 3 marks • Procedure – 8 marks • Results – 2 marks • Conclusion – 3 marks Teachers must use the mark grid for this unit to mark candidates' work. Further marking guidance will be available in our support materials.

7.5 Unit AS 4: Brain Science

Unit AS 4: Brain Science	
Overview	Candidates create a portfolio of evidence demonstrating their knowledge and understanding of brain science and exploring research methods and technologies employed in understanding the function of the brain. Candidates must complete a series of tasks using the guidance that we provide. This is available on our Life and Health Sciences microsite at www.ccea.org.uk
Submission Requirements	Candidates submit a portfolio to demonstrate how they have achieved **all** the learning outcomes, including, as a minimum: • a fact sheet on the structure and functions of parts of the brain, including the effects of damage to specific structures of the brain; • a report of a laboratory experiment investigating materials to protect the brain from contact force injury; • a fact sheet to raise awareness about the causes and effects of stress on teenagers; • an investigation into the causes and effects of stress on teenagers at different key stages, using a questionnaire; • a fact sheet to explain how theory and research into memory can help understand conditions such as dyslexia or dementia; • an experimental investigation on an aspect of memory; • an evaluation of scientific and statistical methods used in the study of the mind and brain; and • an analysis of a specific piece of statistical research data with relevance to mental health in Northern Ireland. Candidates must also complete and submit the portfolio record pro forma, which will include a log of their work against the learning outcomes and the evidence they are presenting for assessment. There is not a specified word limit for this unit; however, the following can be used as guidance: • Fact sheet **500–750 words** • Report **1000–1500 words** • Investigation **1000–1500 words** • Evaluation **500–1000 words** • Analysis **500–1000 words**

Unit AS 4: Brain Science	
Submission Requirements (cont.)	The quality of written communication is assessed. For more details on the specific content that the portfolio should cover, see the learning outcomes in Section 3.4.
Marks and Assessment	There are **80** marks available for this unit: • AO1 – 12 marks • AO2 – 14 marks • AO3 – 54 marks – Practical – 26 marks – Theoretical – 28 marks Teachers must use the mark grid for this unit to mark candidates' work. Further marking guidance will be available in our support materials.

7.6 Unit AS 6: Medicine, Drugs and Clinical Trials

Unit AS 6: Medicine, Drugs and Clinical Trials	
Overview	Candidates create a portfolio of evidence based on the unit content, including an exploration of the problems associated with developing new medicines and their importance in everyday life. The portfolio must include two reports of **1500–2500 words** each. The quality of written communication is assessed. Candidates must complete the two reports using the guidance that we provide. This is available in our candidate guidance documents and other relevant documentation on our Life and Health Sciences microsite at www.ccea.org.uk
Submission Requirements	The evidence that candidates submit must include: • a report on the quantitative analysis of a medicine; and • a report on the bioassay of the medicines outlined in 6.4.2 (see Section 3.6). For more details on the specific content that the portfolio should cover, see the learning outcomes in Section 3.6.
Marks and Assessment	There are **120 marks** available for this unit. Each report is marked out of 60: • AO1 – 8 marks • AO2 – 12 marks • AO3 – 40 marks Teachers must use the mark grid for this unit to mark candidates' work. Further marking guidance will be available in our support materials.

7.7 Unit A2 1: Scientific Method, Investigation, Analysis and Evaluation

Unit A2 1: Scientific Method, Investigation, Analysis and Evaluation	
Overview	Candidates create a portfolio of evidence demonstrating how they have developed skills in carrying out a scientific investigation using scientific methodologies in planning, conducting experiments, data analysis and evaluation of their work. They must complete a scientific investigation to include an essay, plans and a lab book, and report using the guidance that we provide. This is available in our candidate guidance documents and other relevant documentation on our Life and Health Sciences microsite at www.ccea.org.uk The essay should be **1500 words** and the report **1500–2500**. The quality of written communication is assessed in the essay and in the report.
Submission Requirements	Candidates submit a scientific investigation that includes three tasks: • **Task 1: Essay** involves writing a word-processed Harvard-referenced literature review on their chosen scientific investigation (with a maximum of 10 references from a variety of sources). • **Task 2: Plans and Lab Book** includes: – producing a draft project plan (on a spreadsheet) using investigation design principles, with a written summary of its production; – recording a trial of the experimental work in their lab book; – refining the method, approach to health and safety, quality protocol, data analysis techniques and/or any other relevant aspect of the study; – producing an updated project plan for the scientific investigation, incorporating changes arising from the trial study; and – recording the experimental work in their lab book.

Unit A2 1: Scientific Method, Investigation, Analysis and Evaluation	
Submission Requirements (Cont.)	• **Task 3: Report: Investigation, Analysis and Evaluation** must include: – title; – aim/hypothesis; – materials and apparatus; – risk assessment; – method; – results; – conclusion and evaluation; – references; and – appendix. For more details on the specific content that the portfolio should cover, see the learning outcomes (Section 3.7).
Marks and Assessment	There are **80 marks** available for this unit: • Essay – 15 marks • Plans and lab book – 20 marks • Report – 45 marks Teachers must use the mark grid for this unit to mark candidates' work. Further marking guidance will be available in our support materials.

7.8 Unit A2 6: Microbiology

Unit A2 6: Microbiology	
Overview	Candidates create a portfolio of evidence including reports, and a lab book as a record of all the work they have carried out. They must demonstrate that they have taken health and safety into account throughout. Candidates must complete the reports and lab book using the guidance that we provide. This is available on our Life and Health Sciences microsite at www.ccea.org.uk The portfolio of evidence (excluding the lab book) should be **4500–5000 words**.
Submission Requirements	Candidates submit a portfolio to demonstrate how they have achieved **all** of the learning outcomes in this unit. The portfolio should include reports on each of their investigations. They should: • write up the investigations in accordance with the standard laboratory practical report guidelines; • apply the Harvard referencing system; • describe and apply health, safety and environmental methodology to modern standards, in line with current legislation; • describe and apply quality assurance methodology to modern standards; and • maintain a lab book to include a record of the work they are presenting for assessment. For more details on the specific content that the portfolio should cover, see the learning outcomes (Section 3.12).
Marks and Assessment	There are **80 marks** available for this unit: • AO1 – 12 marks • AO2 – 14 marks • AO3 – 54 marks – Practical – 26 marks – Theoretical – 28 marks Teachers must use the mark grid for this unit to mark candidates' work. Further marking guidance will be available in our support materials.

7.9 Unit A2 7: Oral Health and Dentistry

Unit A2 7: Oral Health and Dentistry	
Overview	Candidates create a portfolio of evidence including a completed portfolio record pro forma. They must demonstrate that they have taken health and safety into account throughout. Candidates must complete reports and the portfolio record pro forma using the guidance that we provide. This is available on our Life and Health Sciences microsite at www.ccea.org.uk The portfolio of evidence should be **4500–5000 words**.
Submission Requirements	Candidates submit a portfolio to demonstrate how they have achieved **all** of the learning outcomes in this unit. The portfolio should include reports on each of their investigations. They should: • write up the investigations in accordance with the standard laboratory practical report guidelines or general report guidelines as appropriate to the investigation; • apply the Harvard referencing system; • describe and apply health, safety and environmental methodology to modern standards, in line with current legislation; and • describe and apply quality assurance methodology to modern standards. For more details on the specific content that the portfolio should cover, see the learning outcomes (Section 3.13).
Marks and Assessment	There are **80 marks** available for this unit: • AO1 – 12 marks • AO2 – 14 marks • AO3 – 54 marks – Practical – 26 marks – Theoretical – 28 marks Teachers must use the mark grid for this unit to mark candidates' work. Further marking guidance will be available in our support materials.

7.10 Unit A2 8: Histology and Pathology

Unit A2 8: Histology and Pathology	
Overview	Candidates create a portfolio of evidence including a completed portfolio record pro forma. They must demonstrate that they have taken health and safety into account throughout. Candidates must complete reports and the portfolio record pro forma using the guidance that we provide. This is available on our Life and Health Sciences microsite at www.ccea.org.uk The portfolio of evidence should be **4500–5000 words**.
Submission Requirements	Candidates must explore the work of biochemistry, haematology, microbiology and histopathology departments as detailed in the unit content. Candidates also carry out: • a microbiological analysis; and • **either** a chromatographic **or** an electrophoresis analysis. Candidates submit a portfolio to demonstrate how they have achieved **all** of the learning outcomes in this unit. The portfolio should include reports on each of their investigations. They should: • write up the investigations in accordance with the standard laboratory practical report guidelines or general report guidelines as appropriate to the investigation; • apply the Harvard referencing system; • describe and apply health, safety and environmental methodology to modern standards, in line with current legislation; and • describe and apply quality assurance methodology to modern standards. For more details on the specific content that the portfolio should cover, see the learning outcomes (Section 3.14).

Unit A2 8: Histology and Pathology	
Marks and Assessment	There are **80 marks** available for this unit: • AO1 – 12 marks • AO2 – 14 marks • AO3 – 54 marks – Practical – 26 marks – Theoretical – 28 marks Teachers must use the mark grid for this unit to mark candidates' work. Further marking guidance will be available in our support materials.

7.11 Unit A2 9: Analytical Chemistry Techniques

Unit A2 9: Analytical Chemistry Techniques	
Overview	Candidates create a portfolio of evidence showing how they have developed skills in performing a range of analytical chemistry techniques, including volumetric analysis, chromatography and colorimetry. They must include a completed portfolio record pro forma and demonstrate that they have taken health and safety into account throughout. Candidates must complete reports and the portfolio record pro forma using the guidance that we provide. This is available on our Life and Health Sciences microsite at www.ccea.org.uk The portfolio of evidence should be **4500–5000 words**.
Submission Requirements	Candidates submit a portfolio to demonstrate how they have achieved **all** of the learning outcomes in this unit. The portfolio should include reports on each of their investigations. They should: • write up the investigations in accordance with the standard laboratory practical report guidelines or general report guidelines as appropriate to the investigation; • apply the Harvard referencing system; • describe and apply health, safety and environmental methodology to modern standards, in line with current legislation; and • describe and apply quality assurance methodology to modern standards. For more details on the specific content that the portfolio should cover, see the learning outcomes (Section 3.15).

Unit A2 9: Analytical Chemistry Techniques	
Marks and Assessment	There are **80 marks** available for this unit: • AO1 – 12 marks • AO2 – 14 marks • AO3 – 54 marks – Practical – 26 marks – Theoretical – 28 marks Teachers must use the mark grid for this unit to mark candidates' work. Further marking guidance will be available in our support materials.

7.12 Unit A2 10: Enabling Technology

Unit A2 10: Enabling Technology	
Overview	Candidates create a portfolio of evidence demonstrating research they have conducted. They discuss modern medical equipment and how it improves on prior equipment and methodologies, and they consider the work that is done in a medical laboratory. Candidates present their evidence using a format appropriate to the learning outcome. Guidance is available on our Life and Health Sciences microsite at www.ccea.org.uk The portfolio of evidence should be **4500–5000 words**.
Submission Requirements	Candidates submit a portfolio to demonstrate how they have achieved **all** of the learning outcomes in this unit, including: • a case study of a patient (either real or hypothetical) who requires ongoing medical monitoring; and • a database for ongoing health monitoring, considering the implications of holding such data. Candidates must also complete and submit the portfolio record pro forma, which will include a log of their work against the learning outcomes and the evidence they are presenting for assessment. For more details on the specific content that the portfolio should cover, see the learning outcomes (Section 3.16).
Marks and Assessment	There are **80 marks** available for this unit: • AO1 – 12 marks • AO2 – 14 marks • AO3 – 54 marks – Practical – 26 marks – Theoretical – 28 marks Teachers must use the mark grid for this unit to mark candidates' work. Further marking guidance will be available in our support materials.

7.13 Marking the tasks

Teachers should use their professional judgement to apply the assessment criteria in the mark bands appropriately and fairly to candidates' work. They should take a 'best fit' approach to award the appropriate mark within a range, balancing strengths and weaknesses in each response.

The descriptions assume the continued demonstration of the qualities described in the lower mark bands.

When making assessments, teachers should follow the procedure set out below.

- Make a broad judgement by identifying the mark band that best describes the candidate's achievement.
- This initial judgement should then be further refined. If the criteria have only just been fulfilled, then the work is likely to be worth the marks at the bottom of the mark band.
- If the work demonstrates fulfilment of most of the criteria in a reasonably competent manner, then the work is likely to be worth marks in the middle of the mark band.
- Where the criteria are very competently fulfilled and some evidence of achievement of the higher mark band may be apparent, then the work may be judged to be worth marks at the top of the mark band.
- Teachers must annotate internally assessed work in detail to ensure fairness for candidates and to assist with the moderation process. Annotation should take the form of:
  - summative comments on the work, usually at the end of each section, and on the Candidate Record Sheet; and
  - key pieces of evidence identified throughout the work by annotation either in the margin or in the text.

For up-to-date advice on plagiarism, or any kind of candidate malpractice, see *Suspected Malpractice in Examinations and Assessments: Policies and Procedures* on the Joint Council for Qualifications website at www.jcq.org.uk

7.14 Internal standardisation

Centres with more than one teaching group must carry out internal standardisation of their internal assessment tasks before submitting their marks to us. This is to ensure, as far as possible, that each teacher has applied the assessment criteria consistently. It may be necessary to adjust an individual teacher's marking:

- to bring it into line with that of other teachers in the centre; and
- to match the standards established at the agreement trial.

If marks do change, centres must amend the total/final marks on their Candidate Record Sheets.

7.15 Moderation

Teachers must complete Candidate Record Sheets for all internally assessed units to demonstrate to moderators how all learning outcomes have been evidenced.

Centres must submit their marks and samples to us by early May in any year. We may adjust centres' marking to bring the assessment of candidates' work into line with our agreed standards.

We issue full instructions each year on:

- our moderation procedures;
- which samples we require; and
- the deadlines for submitting marks and samples to us.

Teachers and centre staff may contact us at any stage for advice or support relating to internal assessment.

8 Links and Support

8.1 Support

The following resources are available to support this specification:

- our Life and Health Sciences microsite at www.ccea.org.uk
- specimen assessment materials; and
- guidance notes for teachers.

We also intend to provide:

- past papers and mark schemes;
- Chief Examiner's reports;
- Principal Moderator's reports;
- schemes of work;
- centre support visits;
- support days for teachers;
- portfolio clinics;
- a resource list; and
- exemplification of standards.

8.2 Curriculum objectives

This specification supports centres to build on the broader Northern Ireland Curriculum objectives to develop the young person:

- as an individual;
- as a contributor to society; and
- as a contributor to the economy and environment.

It can contribute to meeting the requirements of the Northern Ireland Entitlement Framework at post-16 and the provision of a broad and balanced curriculum.

Curriculum Progression from Key Stage 4

This specification builds on learning from Key Stage 4 and gives students opportunities to develop their subject knowledge and understanding further.

Students will also have opportunities to continue to develop the **Cross-Curricular Skills** and the **Thinking Skills and Personal Capabilities** shown on the next page. The extent of this development depends on the teaching and learning methodology the teacher uses.

Cross-Curricular Skills

- Communication:
  - Talking and Listening
  - Reading
  - Writing
- Using Mathematics
- Using ICT

Thinking Skills and Personal Capabilities

- Problem Solving
- Working with Others
- Self-Management

For further guidance on the skills and capabilities in this subject, please refer to the supporting schemes of work.

8.3 Examination entries

Entry codes for this subject and details on how to make entries are available on our Qualifications Administration Handbook microsite, which you can access at www.ccea.org.uk

Alternatively, you can telephone our Examination Entries, Results and Certification team using the contact details provided.

8.4 Equality and inclusion

We have considered the requirements of equality legislation in developing this specification and designed it to be as free as possible from ethnic, gender, religious, political and other forms of bias.

GCE qualifications often require the assessment of a broad range of competences. This is because they are general qualifications that prepare students for a wide range of occupations and higher level courses.

During the development process, an external equality panel reviewed the specification to identify any potential barriers to equality and inclusion. Where appropriate, we have considered measures to support access and mitigate barriers.

We can make reasonable adjustments for students with disabilities to reduce barriers to accessing assessments. For this reason, very few students will have a complete barrier to any part of the assessment. Students with a physical impairment may instruct a practical assistant to set up equipment, but they may have difficulty making observations and manipulating the equipment to carry out specific experiments.

Students with a visual impairment may find elements of the assessment difficult. They can use technology to take readings and make observations.

It is important to note that where access arrangements are permitted, they must not be used in any way that undermines the integrity of the assessment. You can find information on reasonable adjustments in the Joint Council for Qualifications document *Access Arrangements and Reasonable Adjustments: General and Vocational Qualifications*, available at www.jcq.org.uk

8.5 Contact details

If you have any queries about this specification, please contact the relevant CCEA staff member or department:

- Specification Support Officer: Nola Fitzsimons
  (telephone: (028) 9026 1200, extension 2235, email: nfitzsimons@ccea.org.uk)

- Subject Officer: Paul Wright
  (telephone: (028) 9026 1200, extension 2207, email: pwright@ccea.org.uk)

- Examination Entries, Results and Certification
  (telephone: (028) 9026 1262, email: entriesandresults@ccea.org.uk)

- Examiner Recruitment
  (telephone: (028) 9026 1243, email: appointments@ccea.org.uk)

- Distribution
  (telephone: (028) 9026 1242, email: cceadistribution@ccea.org.uk)

- Support Events Administration
  (telephone: (028) 9026 1401, email: events@ccea.org.uk)

- Information Section (including Freedom of Information requests)
  (telephone: (028) 9026 1200, email: info@ccea.org.uk)

- Moderation
  (telephone: (028) 9026 1200, extension 2236, email: moderationteam@ccea.org.uk)

- Business Assurance (Complaints and Appeals)
  (telephone: (028) 9026 1244, email: complaints@ccea.org.uk or appealsmanager@ccea.org.uk).

Appendix 1

Mathematical Skills for All Components of GCE Life and Health Sciences

Arithmetic and numerical computation

- Recognise and make use of appropriate units in calculations.
- Recognise and use expressions in decimal and ordinary form.
- Use ratios, fractions and percentages.
- Estimate results.
- Use calculators to find and use power, exponential and logarithmic functions.
- Use calculators to handle sin x, cos x and tan x, when x is expressed in degrees or radians.

Handling data

- Show an awareness of the order of magnitude of physical quantities and make order of magnitude calculations.
- Use an appropriate number of significant figures.
- Find arithmetic means.
- Identify uncertainties in measurements and use simple techniques to determine uncertainty when data is combined.
- Construct and interpret frequency tables and diagrams, bar charts and histograms.
- Understand simple probability.
- Understand the principles of sampling as applied to scientific data.
- Understand the terms mean, median and mode.
- Use a scatter diagram to identify a correlation between two variables.
- Select and use a statistical test.
- Understand measures of dispersion, including standard deviation and range.

Algebra

- Understand and use the symbols =, <, <<, >>, >, ∝, ~, ⇌.
- Change the subject of an equation.
- Substitute numerical values into algebraic equations using appropriate units for physical quantities.
- Solve algebraic equations.
- Use logarithms in relation to quantities that range over several orders of magnitude.

Graphs

- Translate information between graphical, numerical and algebraic forms.
- Plot two variables from experimental or other data.
- Understand that y = mx + c represents a linear relationship.
- Determine the slope and/or intercept of a linear graph.
- Calculate rate of change from a graph showing a linear relationship.
- Draw and use the slope of a tangent to a curve as a measure of rate of change.
- 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.
- Use logarithmic plots to test exponential and power law variations.
- Sketch simple functions, including

$$y = kx,\ y = kx^2,\ y = \frac{k}{x^2},\ y = \sin x,\ y = \cos x \text{ and } y = e^{-x}$$

Geometry and trigonometry

- Use angles and shapes in regular two-dimensional (2D) and three-dimensional (3D) structures.
- Visualise and represent 2D and 3D forms, including 2D representations of 3D objects.
- Understand the symmetry of 2D and 3D shapes.
- Calculate areas of triangles, circumferences and areas of circles, and surface areas and volumes of rectangular blocks, cylinders and spheres.
- Use Pythagoras' theorem and the angle sum of a triangle.
- Use sin, cos and tan in physical problems.
- Understand the relationship between degrees and radians, and translate from one to the other.

Summary of Changes since First Issue

(Most recent changes are indicated in red on the latest version)

Revision History Number	Date of Change	Page Number	Change Made
Version 1	N/A	N/A	First issue
Version 2	11 December 2017	38 110	The word 'non' removed from 'non-renewables' in point 8.2.10 Changes to contact details for the Subject Officer and Subject Support Officer

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