Oxford Cambridge and RSA

Applied AS/A Level GCE

GCE in Applied Science

OCR Advanced Subsidiary GCE in Applied Science H175

OCR Advanced Subsidiary GCE in Applied Science (Double Award) H375

OCR Advanced GCE in Applied Science H575

OCR Advanced GCE in Applied Science (Double Award) H775

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

1 About these Qualifications

This booklet contains OCR's Advanced Subsidiary GCE, Advanced Subsidiary GCE (Double Award), Advanced GCE and Advanced GCE (Double Award) specifications in Applied Science for teaching from September 2013.

The specifications build upon the broad educational framework supplied by the Qualification and Subject Criteria (QCA, DCELLS and CCEA, 2002) and employ an investigative and problem-solving approach to the study of the subject. In addition to providing a suitable route for progression for candidates completing courses in GNVQ or GCSE Science, or GCSE Applied Science, or First Diploma qualifications, the course of study prescribed by these specifications can also reasonably be undertaken by candidates beginning their formal education in the subject at post-16 level. Progression through the Advanced Subsidiary GCE and Advanced GCE, through either a single or double award, may provide a suitable foundation for study of the subject, or related subjects, in further and higher education.

Key Skills are integral to the specifications and *the main* opportunities to provide evidence for the separate Key Skills qualification are indicated.

1.1 The AS GCE

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

The AS GCE is made up of **three** mandatory units which form 50% of the corresponding six-unit Advanced GCE.

The AS GCE (Double Award) is made up of **four** mandatory units and **two** optional units which form 50% of the corresponding twelve-unit Advanced GCE (Double Award).

The skills, knowledge and understanding required for the first half of an Advanced GCE course are contained in the 'Advanced Subsidiary' (AS) units. The level of demand of the AS examination is that expected of candidates half-way through a full Advanced GCE course of study.

1.2 The Advanced GCE

The Advanced GCE is made up of **three** mandatory units at AS and **three** further units at A2.

The Advanced GCE (Double Award) is made up of **four** mandatory and **two** optional units at AS and **six** further units at A2 (**three** mandatory and **three** optional).

The skills, knowledge and understanding required for the second half of an advanced GCE course are contained in the 'A2' units. The level of performance expected, therefore, reflects the more demanding Advanced GCE material, including the higher-level concepts and a requirement to draw together knowledge and skills from across the course. The precise pattern across AS and A2 reflects the nature of individual subjects.

The combination of candidates' attainments on the relatively less demanding AS units and relatively more demanding A2 units lead to an award at Advanced GCE standard.

1.3 Qualification Titles and Levels

These qualifications are shown on a certificate as:

- OCR Advanced Subsidiary GCE in Applied Science.
- OCR Advanced Subsidiary GCE (Double Award) in Applied Science.
- OCR Advanced GCE in Applied Science.
- OCR Advanced GCE (Double Award) in Applied Science.

All qualifications are Level 3 in the National Qualification Framework (NQF).

1.4 Aims

All specifications in Applied Science aim to:

- provide candidates with the opportunity to develop appropriate skills, knowledge and understanding and apply these where science is used;
- enable candidates to appreciate and evaluate the social, economic and environmental impact that scientific work has on society, identifying ethical issues that may arise;
- prepare candidates for further study on a course in science or in a science-related subject or for training in a science-related occupation;
- support and complement other programmes of advanced level study.

The aims of these specifications in Applied Science are to encourage candidates to:

- acquire knowledge and understanding of the scientific ideas and skills that scientists need in order to be effective in their work and to apply this in a variety of vocational contexts;
- become skilful in carrying out practical techniques and following procedures used in vocational contexts;

- develop knowledge and understanding of the science used by organisations, business and industry;
- further develop their interest in science and its practical applications through exploring and experiencing science in a vocational context;
- understand the nature of science-based work and the contribution this use of science makes to society;
- develop an awareness of the use and importance of ICT in scientific work.

In addition, the aims of the Advanced (Single and Double Award) GCE specifications in Applied Science are to encourage candidates to:

- develop their skills of investigation and problem solving in a vocational context, by applying their knowledge and understanding of scientific ideas and techniques, using skills of primary research, planning, data collection, analysis and evaluation.

1.5 Prior Learning/Attainment

Candidates entering this course should have achieved a general educational level equivalent to Level 2 in the National Qualifications Framework, or Levels 7/8 of the National Curriculum. Skills in Numeracy/Mathematics, Literacy/English and Information and Communication Technology will be particularly relevant.

There is, however, no prior knowledge required for this specification. Prior study GCSE Applied Science or GCSE Science will be of benefit to candidates, but is not mandatory. Those who have achieved at Intermediate Level in Science or Applied Science (e.g. GCSE Double Award Science or Applied Science at grades CC or above) will be well prepared to undertake a course in GCE in Applied Science.

2 Summary of Content

2.1 AS Units

Unit G620: *Science at work*

- The importance of health and safety;
- Organisations using science;
- Science and the community;
- Practical techniques and procedures.

Unit G621: *Analysis at work*

- Qualitative analysis;
- Quantitative analysis;
- Energy;
- Efficiency.

Unit G622: *Monitoring the activity of the human body*

- Respiration in energy terms;
- Structure and function of the circulatory and respiratory systems;
- Uses of physiological measurements;
- Methods of taking physiological measurements;
- Imaging methods;
- Regulations governing specific procedures and data management;
- Ethical issues related to monitoring, diagnosis and treatment.

Unit G623: *Cells and molecules*

- Planning an investigation;
- The structure of the cell;
- Some of the molecules found within cells;
- Measuring individual cells and cell populations and the significance of this data;
- Investigating the work of molecular biologists in cellular research.

Unit G624: *Chemicals for a purpose*

- Organic and inorganic compounds;
- The chemistry of oil products;
- Manufacturing processes;
- Preparation and analysis of chemical products.

Unit G625: *Forensic science*

- Recording and collecting evidence;
- Methods of analysing evidence:
  - physical techniques,
  - biological techniques,
  - chemical techniques;
- Evidence and proof.

Unit G626: *The physics of sport*

- Measurement;
- Physics of the body;
- Physics of equipment and techniques;
- Practical techniques and procedures.

2.2 A2 Units

Unit G627: *Investigating the scientist's work*

- Planning an investigation;
- Carrying out the investigation;
- Processing and presenting data from the investigation;
- Evaluating the investigation;
- Presenting the outcomes of the investigation.

Unit G628: *Sampling, testing and processing*

- Identifying the requirements of sampling;
- Obtaining representative samples and correct storage;
- Following a standard testing procedure or devising a suitable test;
- Test methods;
- Evaluating test results;
- Processing in the laboratory;
- Identifying or devising a suitable process;
- Carrying out small-scale processing;
- Evaluating the process.

Unit G629: *Synthesising organic chemicals*

- Organic compounds and functional groups;
- Types of chemical reaction;
- Manufacture and purification of organic compounds;
- Determination of yield and purity;
- Therapeutic drugs and medicines;
- Industrial manufacture of chemical compounds.

Unit G630: *Materials for a purpose*

- Types of materials;
- Physical properties;
- Identification of objectives and constraints;
- Selection.

Unit G631: *Electrons in action*

- Electrochemical change;
- Principles and applications of commercial cells;
- Electrolysis and the extraction of metals;
- Fuel cells.

Unit G632: *The mind and the brain*

- The mind, stress and illness;
- Exploring the healthy and the damaged brain;
- Methods and ethical issues in brain research;
- Everyday cognition.

Unit G633: *Ecology and managing the environment*

- Investigating ecosystems;
- Effects of change on ecosystems;
- Investigating the management of ecosystems.

Unit G634: *Applications of biotechnology*

- The science of genetic engineering;
- Use of recombinant DNA technology in medicine;
- Production of genetically modified food plants;
- Enzyme technology.

Unit G635: *Working waves*

- Types of waves;
- Thermal imaging and other applications of infrared;
- How optical fibres carry data;
- Modern communication systems – how mobile phones and broadband work;
- The work of radiologists X- and γ-ray imaging and therapy.

3 Unit Content

3.1 AS Unit G620: *Science at work*

Scientific research, development and production bring major benefits to improving health care, raising the standard of living and contributing to almost every aspect of daily life. There is a growing awareness of the fragility of the world in which we live, due to pollution, global warming and ozone depletion of the upper atmosphere. Having accepted the benefits of industrial activity, many companies now embrace the need to consider sustainability and environmental impact as part of their long-term development.

In addition to environmental factors, any scientific activity needs to take into account the health and safety of its employees and of the community surrounding it. Industry and governments have long recognised the potential dangers involved in the running of organisations, and there are detailed and comprehensive regulations which cover the raw materials, products, the work and the staff.

This unit will give candidates the opportunity to investigate the importance of science, and the people involved, in a wide range of organisations. Candidates will have the opportunity to investigate the science really used and the type of work actually carried out, and to carry out some standard procedures.

The work in this unit extends knowledge and skills covered in GCSE Applied Science, GCSE Additional Applied Science and/or GCSE Science (Core and Additional).

This unit links to all other units in this qualification. It also links with other GCEs, including Applied Business and Health and Social Care. It can also complement AS units in GCE Chemistry, Biology, Physics and Geography.

This unit will help candidates to prepare for higher education courses in science, science-related NVQs or for work in science-related occupations.

Candidates will produce a research portfolio related to information on organisations that use science. Candidates' evidence will include:

- records of candidate's survey of **four** science-based organisations with an in-depth study of **one** of them and information on health and safety issues;
- information showing an understanding of the impact on society of the candidate's **one** chosen organisation, providing evidence that the candidate has completed relevant calculations *either* using provided data *or* on at least **one** practical procedure carried out;
- evidence that candidates have completed safely **two** practical procedures and recorded, processed and evaluated the results.

3.1.1 The Importance of Health and Safety

Health and safety regulations protect both people who work in an organisation, and people who may be affected by the products or services of the organisation. Regulations, which can be enforced by law, govern the working environment, the processes used and the products made. For individuals working in an organisation, the most important aspect of health and safety is to understand the requirements of the regulation.

The relevant laws and regulations related to health and safety in the workplace include:

- Health and Safety at Work Act, 1974;
- Management of Health and Safety at Work Regulations, 1999;
- Provision and Use of Work Equipment Regulations, 1998;
- Hazard and Critical Control Points as part of the Food Safety Act, 1990;
- Control of Substances Hazardous to Health, 2002;
- Codes of Practices and Recommendations Used in Education (CLEAPSS).

Anything that can cause harm if things go wrong is called a *hazard*. The chance (big or small) of harm actually being done is called a *risk*. Managers make regulations specifically for an individual organisation, based on the knowledge of hazards involved and an assessment of the risks associated with them. Scientific workers need to be able to complete a risk assessment, know the correct action to take to reduce the chance of accidents, and know what to do if an accident does happen.

Throughout the unit, candidates need to demonstrate knowledge of:

- the relevant laws and regulations used by organisations (college, school or place of work);
- how these regulations are monitored;
- the hazards that are involved;
- risk assessments that are completed.

3.1.2 Organisations Using Science

Organisations that use science can be either those that manufacture or process products for sale or those that provide a service.

Production organisations might include those that produce:

- items from plants or from animals, e.g. foods, leather, flowers and plants themselves;
- items from micro-organisms, e.g. beer, wine, dairy foods;
- items from natural raw materials, e.g. ceramics, glass, paper, cement, building materials;
- chemicals and items derived from chemicals, e.g. fertilisers, paints, dyes, plastics, pharmaceuticals;
- mechanical, electrical or electronic devices, e.g. telephones, computer technology, flat screen TV, liquid crystals;
- items used for packaging.

Other production organisations produce materials by:

- extracting or refining resources, e.g. water, gas, oil, coal, gravel, clay;
- generating energy resources, e.g. gas, electricity, nuclear.

Service organisations might include the provision of:

- health care, e.g. hospitals, dentists, opticians;
- health and fitness centres, e.g. gyms, leisure facilities, swimming pools;
- education in science and technology, e.g. in schools, colleges, universities;
- public services, e.g. fire service, police, environmental health, transport, water;
- animal care and welfare, e.g. veterinary surgeries, zoos;
- communications, e.g. TV, radio, mobile phones, satellites, printing and publishing;
- energy, e.g. gas, electricity, nuclear.

Organisations that manufacture or process products may have used scientists in the research and development stages, but the people who produce the products do not need to be scientists, e.g. production workers in the ceramics industry or in a brewery. Sometimes, however, the processes used require scientifically-qualified people to carry them out, e.g. in hospitals, scientifically-qualified staff are needed in improving health care.

Candidates need to demonstrate their research skills by surveying **four** organisations that involve science. The candidates survey needs to include both production and service providers.

For each organisation candidates survey, candidates need to:

- state the products made or the service offered;
- describe the type of work that takes place;
- identify the science that is involved;
- state any legal/health and safety constraints on the organisation.

Candidates need to study **one** of these organisations in depth and:

- explain the nature of the work done, i.e. details of what is produced or the service provision;

- give the number of people employed and the range of staff that are employed;
- focus on the roles, responsibilities, skills and qualifications of the scientifically-qualified staff and how these staff are used within the organisation;
- discuss the science involved in the daily running of the organisation, in any services or products used or made, and its importance;
- describe how the work is supported, e.g. research, quality control, training, use of ICT;
- describe the relevant health and safety laws and regulations used by the organisation and how they are monitored.

3.1.3 Science and the Community

Science is involved in all aspects of our lives, and the organisations that use science impact on the environment and the community. In general, people do not have the background knowledge which would enable them to make balanced judgements regarding the global effects of new research and technology. However, organisations are still required to manage their impact on both the community and the environment.

Applications of scientific knowledge can be detrimental as well as beneficial. We are often faced with a bewildering amount of data relating to issues that concern us, such as synthetic drugs, food additives, genetic engineering, irradiation of food etc., which often leads to disagreement between scientists over the benefits of science.

The impact of an organisation on society is important; the candidates in-depth study needs to include how the candidates' chosen organisation:

- contributes to the economy;
- manages its waste materials;
- uses ICT in data management;
- controls energy consumption;
- makes demands on transport and communication systems;
- effects on the community and the environment;
- impacts in terms of employment;
- manages relevant costs (if available);
- benefits our society (include local, national and global if possible).

3.1.4 Practical Techniques and Procedures

Scientific knowledge and skills may be applied in many different ways within organisations, e.g. many people are involved with science to support education, whereas others could be analytical scientists, or involved in research. It is, however, extremely important that standard procedures are followed and health and safety guidelines are enforced.

Candidates need to demonstrate their practical skills by performing **two** procedures that show a vocational link or relate to production or service organisations involved with science.

For these tasks candidates need to:

- show evidence of the vocational aspect of the practical activity;
- identify hazards and carry out a risk assessment;
- follow set procedures;
- make and record any observations or measurements;
- process and evaluate the results;
- carry out any relevant calculations;
- present information clearly and logically checking spelling, punctuation and grammar.

3.2 AS Unit G621: *Analysis at work*

Whether your industry is a producer, or a service provider, there will always be a need for analysis and quality assessment to track efficiency and provide positive feedback for continued improvement and productivity. In a science-based industry, other forms of analysis may well be utilised for process monitoring and research and development.

Scientists are employed to analyse and identify all kinds of substances. These may be samples taken from the environment (air, water, rocks, soil), living organisms or from production processes in the laboratory or industrial manufacture. They also compare efficiencies of energy resources (consumable and renewable), research environmental impact and control energy transfers within their processes.

In recent years, the uses of ICT in the scientific industry have increased enormously. Most chemical analyses, both qualitative and quantitative, have a large measure of computer input. This includes applications in mass spectroscopy and in emission and absorption spectroscopy. Much use is made of computer library data in the identification of compounds and in the interpretation of spectra.

Computer control is an essential part of the complex electrical generating and transmission systems, both in this country and, increasingly, with other European countries.

By studying this unit, candidates will understand the principles of analytical techniques used in forensic, pathology and research laboratories, and also in the chemical and energy industries.

The work in this section extends knowledge and skills acquired in GCSE Core and Additional Science and Applied Science.

There are links between this section and AS and A2 units in GCE Geography, Chemistry and Physics. There are also links with G620: *Science at work*, G624: *Chemicals for a purpose*, G625: *Forensic science*, G626: *Physics of sport* and G631: *Electrons in action*.

The section will help candidates to prepare for higher education courses in physics, chemistry, environmental science, economics or geography, or for work relating to the energy industry, materials technology, forensic science, or analysis techniques. It could also prepare candidates for work in the materials industry, forensic science service or environmental protection services. It will also provide background for evaluating energy policies in all areas of work.

Candidates' evidence will include:

- relevant research, understanding and detail in a study of **one** organisation to produce a report for that organisation which considers their energy policy and energy usage. The report also includes considerations of energy efficiency and environmental impact;
- a study of large-scale and small-scale generation, to include energy transfer involved. Work to show data and calculations of fuel/energy costs;
- evidence that candidates have safely completed **three** practical analyses, to include a range of both qualitative and quantitative analysis, each will be appropriately recorded, processed and evaluated.

3.2.1 Qualitative Analysis

There are many molecules that may be identified using relatively simple chemical tests and/or by the use of infrared spectroscopy. Chemical analysis is the key to investigating unknowns and confirming the components of chemical compounds. Analytical chemists and forensic scientists are amongst the professionals that use chemical analysis. Mixtures of compounds may be separated and the components identified using a technique called chromatography. A range of chromatography techniques are used in both forensic and industrial applications. These range from basic paper and thin layer chromatography to high performance gas-liquid chromatography.

Candidates need to:

- carry out chemical tests (including flame tests) to identify the following cations: iron (II), iron (III), copper, aluminium, sodium, potassium, calcium, zinc, ammonium;
- carry out chemical tests to identify the following anions: chloride, bromide, iodide, sulfate, nitrate, carbonate;
- carry out chemical tests to identify the following functional groups: >C=C<, $-CH_2OH$, -CHO, >C=O, -COOH;
- use infrared spectroscopy to identify the presence of the following functional groups: $-CH_2OH$, -CHO, -COOH;
- describe the chemical reactions that are involved in the tests listed above;
- identify uses of chemical tests in qualitative analysis and their limitations;
- use chromatography to separate mixtures and identify their components;
- explain the basic principles of chromatographic separation (absorption and distribution), its uses and limitations;
- carry out chromatographic separations using thin layer chromatography and paper chromatography;
- interpret chromatograms.

3.2.2 Quantitative Analysis

Titrations have been the 'bread and butter' of quantitative analysis for a long time. They are still used extensively in environmental, industrial and research laboratories, e.g. the purity of aspirin samples is checked by volumetric analysis in pharmaceutical laboratories or colorimetric analysis can be used to find the percentage of a particular metal in an alloy.

Candidates need to know how to:

- describe, carry out and interpret the results of simple volumetric analyses;
- find the limits of detection of a volumetric analysis;
- prepare standard solutions;
- carry out a normal titration (acid-base, redox);
- carry out the necessary calculations using balanced chemical equations and amounts of substance (moles);
- describe the principles of colorimetric analysis;
- use colorimetric analysis to find the percentage of a particular components in a sample.

Candidates need to be able to demonstrate their practical skills by performing **three** practical activities.

In each of their reports, candidates need to:

- show the link to the vocational context;
- carry out a risk assessment;
- make and record any observations or measurements;
- process and evaluate the results;
- present information clearly and logically, checking spelling, punctuation and grammar.

3.2.3 Energy

In chemical reactions, energy can be transferred from molecule to molecule by the making and breaking of chemical bonds. One key area that depends on such energy releases is in the burning of fossil fuels. The rate of consumption of fossil fuels continues to rise. Their supply is limited and, despite discoveries of new resources under the ground, their prices will rise in future. Energy consumption in all organisations is an essential consideration. Energy policies are now important in the management of all types of organisations.

Candidates need to:

- use ideas of transfer of energy during breaking and making of chemical bonds between particles to explain why some chemical reactions are exothermic and some are endothermic;
- investigate enthalpy of combustion of different fuels;
- do any calculations from data researched;
- research data on energy values and fuel costs;
- investigate energy policies and energy saving practices of non-domestic consumers of electricity;
- discuss forms of energy transfer;
- include a comparison of relative benefits and problems of large-scale (large power station) and small-scale (e.g. small community use of wind or solar generation) electrical generation.

3.2.4 Efficiency

The efficiency of a system is an important measure as to how well energy is transformed from one form to another. The efficiency of burning fossil fuels is therefore of enormous immediate, and future, economic and environmental importance, due to their limited supply.

Candidates need to:

- explain what is meant by efficiency;
- explain why actual efficiency will always be less than the theoretical maximum;
- investigate steps that could be taken by a non-domestic consumer to maximise efficiency of energy use.

Candidates need to produce an energy efficiency report on an organisation they have chosen to study. Candidates need to use accurate nomenclature, terminology, units and include correct spelling, punctuation and grammar.

Candidates' reports needs to include:

- information from a non-domestic consumer stating their energy policy;
- research on energy efficiency and how a non-domestic consumer of energy considers this;
- an assessment of the economic and environmental impacts of their chosen organisation;
- a study of large-scale and small-scale generation, to include energy transfer involved;
- information to include data and calculations to show fuel/energy costs.

3.3 AS Unit G622: *Monitoring the activity of the human body*

People working in the health care and related industries need to gather data and information about their clients, in order to give treatment, care and advice.

There are a lot of important techniques that are used to collect valid data and information about the functioning of the human body. This information is essential for the diagnosis and care of many disorders. Monitoring the activity of organs and analysing samples of body tissue and fluids can produce information about what is happening inside the human body. This section also introduces elementary ideas about image formation and digital imaging used in the medical context.

Data and information needs to be collected reliably. It also needs to be related to norms based on the expected performance of healthy bodies of the same age, gender and physical dimensions. These norms will have a variety of ranges of performance.

The work in this unit extends the knowledge and skills acquired in GCSE Science and Applied Science. It is supported by G620: *Science at work*, G623: *Cells and molecules*, G625: *Forensic science* and G626: *The physics of sport*, and complements G635: *Working waves*.

This unit will help to prepare candidates for vocational or higher education courses that include work on human biology, health or sport science. It could also prepare candidates for work in the health or leisure areas, or in the sports industry.

3.3.1 Respiration in Energy Terms

Cellular respiration is the process by which every living cell obtains energy for its activities. This makes it a useful process to target when monitoring the general state and activity of the human body.

Candidates need to:

- compare cellular respiration to the burning of fuels;
- describe how the circulatory and respiratory systems both play a part in the process of respiration;
- outline why humans need to respire, with reference to muscle cell contraction, nerve impulse transmission, active transport and metabolic reactions;
- state that ATP provides the immediate source of energy for biological processes;
- state the differences between aerobic and anaerobic respiration in terms of their location within cells, substrates, products and quantity of energy made available to a respiring cell;
- relate cellular respiration to what happens in a muscle cell during various levels of physical activity;
- explain how monitoring a person's circulatory and respiratory systems and analysing their blood provides information about a person's state of health or fitness.

3.3.2 Structure and Function of the Circulatory and Respiratory Systems

The way in which the heart and lungs of an individual are functioning can give a good indication of the general state of health of that person. Heart rate, ventilation rate and the chemical state of the blood in circulation are useful physiological indicators. It is therefore important that candidates know something about the structure of the cardiovascular and respiratory system and the way they work.

Candidates need to:

- describe the structure of the heart, the roles of the **four** chambers, the position and function of valves in double circulation, and the characteristic features of arteries, veins and capillaries;
- explain how heart rate is affected by nervous and hormonal inputs;
- explain how blood pressure changes with the activity of the body, and the effect of carbon dioxide levels in the blood;
- describe the structure of the lungs, trachea and bronchial tubes, and how ventilation is brought about by muscles;
- explain how gases are exchanged between the atmosphere and the blood through the respiratory surfaces of the lungs;
- explain how oxygen and nutrients reach the cells within tissues, and how carbon dioxide is removed from the cells and from the bloodstream.

3.3.3 Uses of Physiological Measurements

Physiological indicators measured in a hospital or a fitness clinic can be used to check a person's state of health and general fitness, to check whether they are recovering from an injury or operation or to help follow the progress of a clinical condition.

Candidates need to:

- explain why you need to know the average values and ranges for physiological indicators that are regarded as 'normal' for male and female adults at rest;
- state that the typical blood plasma concentration (fasting level) is 3.5 – 7.5 mmol dm^{-3} and that glucose appears in the urine when the blood plasma concentration exceeds 9.0 mmol dm^{-3};
- state the following values or ranges relating to breathing:
  – breathing rate, 15 – 18 breaths per min;
  – tidal volume, 0.4 – 0.5 dm^3;
  – vital capacity (male), 6.00 dm^3;
  – vital capacity (female), 4.25 dm^3;
  – peak flow, 400 – 600 dm^3;
- state the following blood pressure values:
  – typical 18-year-old adult 120/80 mmHg;
  – male. aged 20 years, 125/80 mmHg;
  – female, aged 20 years, 123/80 mmHg;
  – male, aged 40 years, 135/85 mmHg;
  – female, aged 40 years, 133/85 mmHg;
- state the following values or ranges for body temperature (mouth):
  – normal 36.8 ^oC (range 36.5 to 37.2 ^oC);
  – death, below 25 ^oC;
  – hypothermia, below 32 ^oC;
  – fever, above 37.2 ^oC;
  – hyperthermia/heat exhaustion/heatstroke, likely if above 38 ^oC in the absence of infection;
  – above 43 ^oC , temperature likely to be fatal;

- state that the typical range for pulse rate is 60 – 80 beats per minute;
- describe how blood cell counts can be useful in diagnosis, e.g. red blood cell counts for anaemia and white blood cell counts for leukaemia;
- distinguish between type 1 (insulin dependent) and type 2 (non-insulin dependent) diabetes (details of insulin action are **not** required);
- describe the link between type 2 diabetes and diet;
- state the link between 'early onset' diabetes and obesity in children and young adults;
- state the principles of how blood-sugar monitoring is used in the treatment of diabetes;
- state the principles of how breathing tests of, for example, tidal volume and peak flow rate are used in the treatment of asthma;
- state the principles of how blood tests are used to find the following chemicals in the blood:
  – alcohol;
  – a named recreational drug;
  – a named performance-enhancing drug;
- state the principles of how blood tests, including ELISA tests, are used to find antibody indicators for diseases, for example, hepatitis, AIDS;
- state that a sphygmomanometer can be used to monitor blood pressure and that an electrocardiograph, spirometer and peak-flow meter can be used to monitor the activity of the heart and lungs;
- recognise, for each instrument, a normal trace (or the average value in the case of a sphygmomanometer and the maximum value for a peak-flow meter) and describe what each shows;
- recognise traces for normal heart, sinus tachycardia, bradycardia, sinus arrhythmia and ventricular fibrillation;
- describe what electrocardiograph and spirometer traces and sphygmomanometer and peak-flow meter readings show about the probable physiological status of people;
- recognise the normal body temperature for an average adult at rest, the range that a healthy body can withstand in the context of hypothermia and hyperthermia, and body temperatures that are dangerously high or low due to medical conditions;
- describe the mechanisms available to the body to maintain a stable body temperature including shivering, sweating, vasoconstriction and vasodilation.

3.3.4 Methods of Taking Physiological Measurements

Physiological indicators are measured in a variety of ways. Measuring equipment used in this area varies in complexity. However, in general they are relatively user-friendly.

This sub-section provides many opportunities to explore the use of ICT in physiological investigation. Physiological data collected using electronic equipment can be stored for information as patient records, presented as graphs or charts for use in diagnosis or general health assessment.

Candidates need to:

- explain how to take pulse-rate measurements;
- describe how to assess a person's current level of fitness and whether their performance is improving, using pulse-rate measurements taken before, during and after exercising;
- explain how to measure blood-pressure using a manual sphygmomanometer and an electronic digital sphygmomanometer;
- explain how to measure breathing rate;
- explain how to measure tidal volume and vital capacity of the lungs (using a simple spirometer);
- explain how to measure peak expiratory flow rate using a peak flow meter;
- explain how to measure body temperature accurately;
- describe procedures for the diagnosis of type 2 diabetes, with reference to the fasting blood-glucose test and glucose tolerance test;
- outline the way biosensors are used to monitor blood-glucose levels;
- use graphs to monitor changes in pulse rate, blood pressure, temperature and breathing rate.

3.3.5 Imaging Methods

Technology has provided us with some very important diagnostic tools. Surgery is more successful thanks to information gained from pre-operative, non-invasive diagnosis.

This sub-section concentrates on the production of images using electronic monitoring devices. Candidates will become acutely aware of the significance of computer technology in modern medicine in terms of data attainment, management and use in diagnosis.

Candidates need to:

- explain the basic principles of medical X-ray radiography;
- describe how CAT scans and MRI scans are used for diagnosis;
- explain the basic principles of ultrasound scanning and how ultrasound scans may be useful in diagnosis;
- distinguish between different types of medical scanner used in diagnosis, to include X-ray, ultrasound, CAT and MRI.

3.3.6 Regulations Governing Specific Procedures and Data Management

Health and Safety issues in the work place make it essential that good practice guidelines are clearly stated and understood.

Candidates need to:

- describe regulations for the disposal of hazardous biological waste, e.g. sharps and hypodermic needles used in obtaining blood for testing;
- describe and explain procedures for the treatment of material that may be contaminated with microbiological hazards, e.g. used petri dishes, materials from antibody testing;
- design a risk assessment for a blood test, stating what the hazards are, and explaining how to minimise the risk from these hazards **to the person carrying out the blood test**;
- design a risk assessment for any other non-invasive physiological measurement, e.g. heart rate measurement, stating what the hazards are and explaining how to minimise the risk from these hazards **to anyone involved**;
- be able to choose and evaluate relevant sources of data;
- be able to obtain and use primary and secondary data.

3.3.7 Ethical Issues Related to Monitoring, Diagnosis and Treatment

It is important to be aware that the decision to carry out a program of diagnosis and treatment involves consideration of other issues that might affect the patient. It may not be a simple case of medical expedience.

Candidates need to:

- discuss the risks, benefits and ethical issues involved in using imaging methods;
- identify the risks and benefits arising from the diagnosis and/or treatment of patients with circulatory or respiratory disorders;
- identify situations where it may be considered inappropriate to diagnose and/or treat patients.

3.4 AS Unit G623: *Cells and molecules*

Molecular biologists study how cells work at the molecular level, and try to understand how the relationship *between* all of the different molecules can produce a functioning, living unit – the cell.

In recent years, this branch of science has become increasingly important in our understanding of disease, and in finding ways to treat and even cure some of the major diseases that affect human beings. Research into DNA has given us a greater understanding into the way living organisms work. The *Human Genome Project* has finally produced a database of the coding of DNA for a human being. This knowledge has not only provided us with great power, but also great responsibility as to how this knowledge should be used. It is only by understanding the science behind these discoveries that society will be in a position to make responsible decisions as to how this knowledge should be used.

By studying this unit, candidates will understand some of the principles involved in how cells work, and investigate some of the molecules that are found within the cell. Candidates will also learn some of the techniques used when studying cells within industrial research and pathology laboratories. Finally, candidates will consider some of the moral and ethical implications of such research and how this can affect individuals within society.

The work in this unit extends the knowledge and skills covered in GCSE Science and GCSE Applied Science.

There are strong links between this unit and units in GCE Biology and Chemistry. There are also strong links with G622: *Monitoring the activity of the human body* and G627: *Investigating the scientist's work*.

This unit will help candidates to prepare for higher education courses in biology, chemistry or molecular biology, or for work into medical-related occupations. It will also provide the background and understanding to make rational, moral and ethical decisions about the implementation of some aspects of genetic and cellular research.

The nature of the investigation will be specified by OCR and should be presented to candidates **six** weeks before the external examination. The task set will call on the knowledge and skills associated with any of the areas of study specified in G622: *Monitoring the Activity of the Human Body* and this unit, G623: *Cells and Molecules*.

Candidates are not expected to carry out the investigation but may find some of the assessment objectives more easily accessed if candidates do so.

Candidates will be expected to hand in their investigation plan on a date specified by their teacher which will be no later than the date of the examination.

3.4.1 Planning an Investigation

Professional biologists, chemists and molecular biologists are continually carrying out research into the structure and functioning of the cell.

Candidates need to plan a practical investigation in which they:

- include a risk assessment to show how the investigation will be carried out safely;
- make a prediction and produce justification in support of their prediction;
- describe and explain the reasoning behind any preliminary work carried out;
- identify relevant secondary sources of information used;
- plan how to use appropriate techniques to carry out a detailed practical investigation;
- list the equipment required;
- state the number and range of measurements to be undertaken;
- identify any variables that could affect the validity of any conclusions made;
- explain how variables will be controlled;
- show how you would present and display the data you could collect using appropriate methods;
- indicate how the data will be analysed;
- evaluate the investigation.

3.4.2 The Structure of the Cell

Molecular biology is the study of the molecules and the chemical interactions that occur within cells. The cell is a complete and functioning biological unit that acts as a building block for all living things. In order to understand how the cell works, we need to look at some of the structures found within the cell and understand the role that each plays in the successful functioning of the cell.

Candidates need to:

- describe how to produce a slide of a cellular tissue, as a temporary mount, and describe the structures observed within a cell using a light microscope;
- describe the additional structures observed using an electron microscope;
- explain the functional differences between a light microscope and an electron microscope;
- describe the role of the cellular organelles found in animal and plant cells.

3.4.3 Some of the Molecules Found Within Cells

In order to fully understand cells, we not only need to understand the ultrastructure of a cell but also the role of some of the chemical molecules found within it. These molecules range from the simple water molecule to the more complex polymer of DNA that is found within the nucleus. Scientists also need to carry out chemical tests for the presence of these molecules when analysing the contents of cells.

Candidates need to:

- describe and explain the function and importance of water as a biological molecule;
- describe the process of osmosis, and explain how cells maintain their correct water balance;
- describe and explain the importance of carbon in biological molecules;
- describe, with the aid of diagrams, the structure of carbohydrates to include the formation (condensation) and breaking (hydrolysis) of glycosidic bonds;
- describe how to carry out tests for reducing sugar (Benedict's test), non-reducing sugar (Benedict's test after acid-hydrolysis), and starch (iodine solution);
- describe, with the aid of diagrams, the structure of lipids and phospholipids, to include the ester bond, and saturated and unsaturated fats;
- describe the role of phospholipids in the structure of the cell membrane, to include the fluid mosaic model;
- describe how to carry out an emulsion test for lipids;
- describe the structure of proteins to include the peptide bond, alpha helix and beta pleated sheets, primary, secondary, tertiary and quaternary structures and the formation of globular proteins;
- describe how to carry out a test for proteins (biuret test);
- state that enzymes are globular proteins, with a specific tertiary structure, which catalyse metabolic reactions in living organisms;
- describe the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity;
- describe how the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity can be investigated experimentally;
- state that deoxyribonucleic acid (DNA) is a polynucleotide, usually double stranded, made up of nucleotides containing the bases adenine (A), thymine (T), cytosine (C) and guanine (G);
- state that a gene is a sequence of DNA nucleotides that codes for a polypeptide;
- outline the roles of DNA in living organisms (the concept of protein synthesis must be considered in outline only).

3.4.4 Measurement of Individual Cells and Cell Populations and the Significance of this Data

An important skill is the ability to accurately measure the size of cells, count the numbers of cells on a microscope slide and calculate the number of cells in a given volume of liquid. Scientists who work in pathology laboratories in hospitals often need to know the relative numbers of red and white blood cells in samples of blood as this can provide valuable information for the diagnosis of certain diseases and conditions.

Candidates need to describe and explain:

- how to use an eyepiece graticule to determine the relative sizes of different cells or tissue structures;
- how to use a stage micrometer to determine actual dimensions of cells;
- how to use a haemocytometer to determine the number of cells in a specific volume of liquid;
- how and why the brewing industry and pathology laboratories use Coulter counters;
- how and why scientists in biomedical research and pathology laboratories study cells, cell counts and manifestations of cell changes.

3.4.5 Investigation of the Work of Molecular Biologists in Cellular Research

Candidates need to:

- describe and explain how cell counts can be used in the investigation of anaemia and leukaemia;
- describe how cervical smear tests are analysed in a hospital pathology laboratory for positive and negative results;
- describe the clinical symptoms of cystic fibrosis and Huntington's chorea, as examples of genetic disease, and their effect on the individual;
- explain the diagnostic tests, to include the use of monoclonal antibodies, that can be used to identify diseases;
- discuss the moral and ethical implications of diagnostic testing for genetic disorders.

3.5 AS Unit G624: *Chemicals for a purpose*

The chemical industry is one of the UK's most successful large industries. Chemicals are manufactured for a range of uses including pharmaceuticals (medicines), detergents, paints, fertilisers, fuels and petrochemicals, and specialist consumer goods.

Chemists working in the industry have many roles. They synthesise new chemical products, work with engineers to design and run chemical manufacturing processes, and analyse products for safety and quality. Many chemists are employed as consultants for sales and advertising.

In studying this unit, candidates will learn about the range of chemicals manufactured in the UK. Candidates will learn about the chemistry behind making manufacturing-processes operate efficiently, and how the conditions they use are chosen. Candidates will study the properties and actions of examples of chemical products used in consumer goods (such as detergents) and will prepare and analyse a sample of two products (one organic and one inorganic) on a laboratory scale.

The work in this unit extends the knowledge and skills covered in GCSE Core and Additional Science and GCSE Applied Science. There are strong links between this unit and G621: *Analysis at work*, G629: *Synthesising organic chemicals*, G630: *Materials for a purpose* and AS units in GCE Chemistry.

The study of this unit is important if candidates want to progress on to degree courses in chemistry or chemical engineering, or into occupations using chemistry.

Candidates will provide evidence of their knowledge, understanding and investigation into chemicals for a purpose. Candidates' evidence will include:

- a description of **two** examples of inorganic and **two** examples of organic chemical products, discussing their uses, properties and chemical structure. Candidates will include a detailed account of the chemistry of two compounds, one of which is made from oil, showing how their structures and chemistry relate directly to their uses;
- an example of **one** industrial process that involves the use of a catalyst, whose action candidates will explain. Candidates will show an understanding of the social, economic and environmental impact of the product produced in the process;
- a sample and account of the preparation of each of **two** products (one inorganic and one organic) that have been synthesized, purified and analysed in the laboratory.

3.5.1 Organic and Inorganic Compounds

The chemical industry produces both organic and inorganic compounds. These have different properties and so are used in different ways. Chemists represent compounds using different types of formulae and research the properties of compounds to work out how they can be used.

Candidates need to learn about the range of chemicals produced by the chemical industry.

Candidates need to:

- know the difference between organic and inorganic compounds;
- understand the difference in properties between ionic and covalent compounds;
- recognise formulae for a range of inorganic compounds used and made in industry:
  - common acids and alkalis (including ammonia);
  - carbonates, chlorides, hydroxides and sulfates of sodium, potassium, calcium, magnesium, aluminium, iron, copper and zinc;
  - oxides of the metals listed above and those of carbon and sulfur;
- draw and recognise structural formulae for a range of organic compounds:
  - hydrocarbons – simple alkanes, alkenes and benzene;
  - alcohols;
  - carboxylic acids and esters;
- find and use information about chemical and physical properties, such as reactivity, solubility, melting points, boiling points and state, to classify compounds as ionic or covalent;
- research preparative methods of chosen compounds;
- know the range of uses of some of the compounds that candidates study;
- evaluate the use of a compound in terms of its properties.

3.5.2 The Chemistry of Oil Products

The way that chemical products are used depends on their properties and reactions. Chemicals from oil are called petrochemicals. Oil is used as a raw material for making huge amounts of the chemicals we use everyday, including plastics, synthetic fibres and detergents.

In learning about oil products, candidates need to:

- know the names and uses of some chemical products from petrochemicals, e.g. esters, polyesters, addition polymers;
- research the chemistry of addition and condensation polymers in terms of their formulae, structure, preparation, properties and uses, e.g. polyethene, polystyrene, PVC, PTFE, nylon;
- describe the reaction that happens during addition polymerisation and condensation polymerisation, and outline how these are carried out on an industrial scale;
- research the processes involved in the petrochemical industry, e.g. distillation, cracking, reforming, addition.

3.5.3 Manufacturing Processes

Some chemicals are produced on a very large scale. These processes need to run as cheaply and efficiently as possible, and also need to follow environmental considerations. Chemists design these processes to use as little energy as possible. One way of lowering energy demand is to use catalysts. Catalysts are used in the manufacture of fertilizers, plastics, fuels and many other materials.

Candidates need to research and study some large-scale chemical processes that involve the use of catalysts.

Candidates need to:

- explain how catalysts work;
- know the difference between homogeneous and heterogeneous catalysts and outline the advantages and disadvantages of each;
- discuss how catalysts increase efficiency and lower energy costs;
- research industrial processes in which catalysts are used e.g. Haber process, Contact Process, and know that catalysts are widely use in the petrochemical industry e.g. in reforming, cracking and polymerization.
- research and evaluate the conditions of chemical processes by considering the advantages and disadvantages of a process for making a chemical product e.g. energy costs, waste products, availability and sustainability of raw materials.

3.5.4 Preparation and Analysis of Chemical Products

Chemists working to develop new products initially prepare small samples of chemicals which are then tested. Candidates need to prepare **two** chemicals on a laboratory scale; one should be an **organic** compound and the other an **inorganic** compound. Candidates will then carry out tests to analyse the compounds.

Candidates will need to:

- research and use the appropriate techniques to safely carry out the laboratory preparation (techniques could include, vacuum filtration, distillation, refluxing);
- make a full risk assessment to cover the procedures and the substances;
- use chemical equations to calculate the
    - (i) amount of reagents to be used
    - (ii) amount of product which will be prepared
    - (iii) theoretical yield;
- research and use the appropriate techniques to safely purify and analyze the products;
- calculate the percentage yield;
- evaluate the processes used and suggest any appropriate adaptations to the method that could increase the yield.

3.6 AS Unit G625: *Forensic science*

Forensic science is any science that is used in courts of law. It can therefore cover almost any area of science.

The basic principle of forensic science, 'that every contact leaves a trace', was identified by one of its pioneers, Edmond Locard. By studying this unit, candidates will learn how this evidence is collected and the basic science underpinning the analysis of the main types of forensic evidence that may be presented in court. Candidates will carry out simple forensic analyses, acquiring knowledge of more complex procedures, and report the results. Candidates will evaluate the reliability of different types of forensic evidence in securing a conviction.

Candidates need to report on a forensic case study, in which they will evaluate the quality of the types of evidence obtained and the strengths and weaknesses of the analytical methods used.

This unit extends the knowledge and skills covered in GCSE Science and GCSE Applied Science. There are strong links between this unit and units in GCE Chemistry. This unit complements G620: *Science at work*, G622: *Monitoring the activities of the human body* and G635: *Working waves*. There are also strong links with G623: *Cells and molecules*. Because of their multi-disciplinary approach, forensic investigations also lend themselves to synoptic assessment and so are suitable for use in G627: *Investigating the scientist's work*. This unit will help to prepare candidates for higher education courses in forensic science.

Candidates will conduct an investigation into forensic science. Candidates' evidence will include:

- a knowledge and understanding of the need to preserve and record the crime scene, and the physical, biological and chemical techniques used to collect and visualise forensic evidence safely, including ethical considerations;
- a report based on a forensic case study, on evidence and proof, and work which demonstrates the use of calculations to support forensic measurements or observations;
- at least **one** forensic analysis in **each** of the following areas:
  – physical;
  – biological;
  – chemical.

3.6.1 Recording and Collection of Evidence

Forensic science begins at the scene of crime. If the investigator does not recognise evidence and record it in place at the crime scene or preserve it for later analysis in the laboratory, no amount of sophisticated laboratory equipment can resurrect the situation and make the evidence or findings admissible in court.

Candidates need to:

- describe and explain the need to preserve and control the crime scene;
- describe and explain the need to record the crime scene using, e.g. sketches, video, photography, digital imaging, thermography.

The search for evidence at the scene of the crime needs to be systematic and thorough. Evidence can be large objects or on a microscopic scale. The presence of some evidence, such as latent fingerprints, blood or hairs, can only be revealed by techniques used at the scene of crime or by analysis in the laboratory. In many instances, the modern forensic scientist has a range of options for the visualisation of evidence and selects the best method for the situation.

All evidence needs to be packaged separately and handled so that changes are prevented from taking place.

Candidates need to:

- describe **physical techniques** e.g. use of adhesive tape, forceps, plaster casts, vacuuming for the safe collection of evidence and recognise the situations in which these techniques are used (collecting hair samples, fibres, footprints, tool marks, tyre prints);
- describe **biological techniques** e.g. taking blood samples, breath samples, tissue samples, urine samples, swabs from the mouth, body or personal items for the safe collection of evidence and recognise the situations in which these techniques are used (DNA analysis, alcohol from suspected drink-drivers, drugs and toxins in suspects and at post-mortem);
- describe **chemical techniques** e.g. solvent extraction, chemical sample collection (liquid or solid) for the safe collection of evidence and recognise situations in which these techniques are used (for accelerants, drugs and toxins in tissue samples, explosives, and inks from forged documents);
- explain how the precautions taken during collection prevent contamination of evidence;
- discuss the ethics of retaining samples and data (DNA, fingerprints) from suspects and those convicted of crime and describe the current legal framework;
- discuss the need for an ethical code for forensic scientists.

3.6.2 Methods of Analysis of Evidence

The methods of analysis used by the forensic scientist must be based on established scientific principles if they are to be admissible in court. These analytical techniques cover a number of scientific disciplines and employ a wide range of techniques. Mathematical competence is also important as various calculations need to be completed by the forensic scientist in order to process data and confirm suspicions.

Physical Techniques

Candidates need to:

- use visual methods to match fingerprints, footprints, tool marks, tyre prints;
- describe the use of dental records in identification;
- describe how test firings can identify the weapon used in a crime;
- use measurements and calculations of refractive index to compare samples of glass;
- use density-gradient methods for comparing samples of soil.

Biological Techniques

Candidates need to:

- explain how insects can be used as biological indicators of time of death and place of death;
- describe the techniques used to identify blood groups (immunological tests) and compare DNA samples (electrophoresis);
- explain why and describe how immunological techniques are used to identify minute traces of drugs in body fluids and body tissues;
- use a microscope to examine evidence (identify natural and man-made fibres, hair structure, the surface structure of pollen grains).

Chemical Techniques

Candidates need to:

- use chemical tests in the identification of organic and inorganic substances;
- describe how chemical tests can be used to identify common explosives and drugs;
- use chromatographic methods to separate mixtures of dyes or inks;
- describe the use of infrared spectroscopy to identify organic substances and materials e.g. fibres, explosives, drugs, poisons;
- explain the use of standards, published values of relative retention times and spectra in drawing conclusions.

3.6.3 Evidence and Proof

From the analyses carried out, the role of the forensic scientist is to provide information previously unknown, or to corroborate information available. The end product of almost any forensic investigation consists of a forensic report. This information may be used by police to trace an offender, or to corroborate other evidence. It may be used by the prosecution, the defence, the judge and ultimately the jury, in a trial. The quality of evidence is paramount. It is dependent on the type of evidence itself, and the level of standards employed by the forensic scientist.

Candidates need to produce a report based on a forensic case study to:

- explain why forensic science professionals collect evidence;
- explain how forensic testing is made objective;
- describe the chain of evidence that may lead to a conviction;
- discuss the scientific strengths and limitations of different types of evidence and analytical techniques in assessing the probability of guilt;
- discuss the need to review evidence in the light of new scientific techniques to overturn miscarriages of justice or establish guilt beyond reasonable doubt.

3.7 AS Unit G626: *The physics of sport*

A sporting event is an experiment to determine the best player or team. It is a complicated experiment, because there are so many variables, but on the day, the result may be determined by some simple measurements.

The popularity of, and participation in, sport is world-wide and it is a multi-billion pound business, with manufacturers spending huge sums on product development and promotion, and successful performers gaining fame and fortune.

Sport provides employment for many people across the world – not only in performance and manufacturing but also in a wide range of ancillary services such as provision of facilities, medicine, catering, publishing, transport and so on.

The range of sports is enormous and encompasses the events of the summer and winter Olympics, professional team games, motor sports, aviation, rock climbing, angling etc.

Where appropriate, candidates should consider ethical issues linked to the content of this unit, e.g. expenditure on materials and developments/spin off for other applications, consumption of raw materials, use of drugs/special diets to enhance performance, improvement of health and fitness of general population.

Competitive players want to monitor and improve their own performance and their equipment. It is often helpful to know why and how things happen.

The unit builds on the content of GCSE Science and Applied Science, especially the work on forces, motion, light and waves. It is supported by G621: *Analysis at work* and G622: *Monitoring the activity of the human body* and complements much of G630: *Materials for a purpose* and G635: *Working waves*.

This unit could be studied simply out of interest, to provide balance in a candidate's AS course, or to prepare for higher education courses which include aspects of sport or physics.

Candidates' evidence will include:

- a series of **four** short guidance leaflets for the coaches at a sport and recreation centre to help them answer questions of a technical nature from their trainees

  I A '*Measurement in Sport*' leaflet which will include the units, devices and techniques used for making measurements of **four** different quantities in specified sports of a candidate's choice;

  II A '*Seeing in Sport*' leaflet which will include the structure of the eye and how it forms an image, related to **one** chosen sport where good vision is of critical importance;

  III A '*Movement in Sport*' leaflet which will include an account of how chemical energy is most efficiently converted into useful mechanical work using the muscles, bones and joints of **one** or more limbs and related to **one** chosen sport where efficient movement is of critical importance;

  IV A '*Technique in Sport*' leaflet which will include **one** example related to a specified sport of their choice of either collisions, trajectories of moving objects or lift, e.g. in aerofoils;

- a presentation aimed at a target audience of Sports Science AS level students to help them understand the materials required for Sports equipment including balls. Candidates need to include the required material properties and how these are achieved in **one** or more other chosen item of sports equipment;

- an account of **two** experimental investigations relating to the physics of sport.

Candidates' evidence will demonstrate that they have used calculations to analyse the physics of sport and information is presented clearly and logically with correct spelling, punctuation and grammar.

3.7.1 Measurement

Most sports events have an element of competition. Large amounts of glory, personal pride and money may depend upon the result. It is important to make accurate measurements to determine who was fastest, highest, strongest, etc.

During training and preparation for an event, sportsmen and women may wish to monitor the performance of their body and their equipment.

Measurements are made by comparing objects or events with internationally-agreed standards.

Candidates need to:

- know the SI units of:
  – mass;
  – length;
  – time;
  – temperature;
  – pressure;
  – force;
  – weight;
  and their multiples and submultiples;
- know the practical units used for measurement in sport, such as:
  – mm Hg;
  – °C;
  – calories;
  and how they relate to the SI units;
- carry out calculations and conversions using SI and other units;
- know about the range of devices and techniques for making measurements in sport and explain the need for calibration and the limitation of these devices:
  – manual clockwork and electronic clocks/stopwatches;
  – mechanical and optical timing gates;
  – rules and tape measures;
  – manometers and pressure cells;
  – mercury/glass thermometers, thermistors;
  – clip-on pulse monitors;
  – radar;
  – data logging;
- carry out and record measurements using sports equipment or laboratory equivalent;
- use formulae and equations to solve problems involving force, mass, acceleration, momentum, work, energy and power;
- use vectors to solve problems involving velocities or forces.

3.7.2 Physics of the Body

The eyes provide much of the information used by sportsmen and women during their performance. Candidates need to examine the physical principles involved in the eye. The musculo-skeletal system functions as a series of connected levers actuated by muscles under the control of the central nervous system (CNS). Candidates need to investigate the mechanical principles involved. The use of energy for movement will be considered.

Candidates need to:

- know the basic anatomy of the eye:
  – cornea;
  – iris;
  – cilliary muscles;
  – lens;
  – aqueous and vitreous humour;
  – retina;
  – rods and cones;
  – optic nerve;
- describe the formation of a real image with a + lens and relate this to the eye;
- describe the optical function of each of the parts of the eye listed above;
- describe the effects of colour filters on white/day/flood light and explain how the use of coloured contact/spectacle lenses may help sports players, e.g. tennis, aviation;
- describe how eye defects can be corrected with the use of lenses and perform calculations to determine the focal length of such lenses;
- know the principle of conservation of energy;
- know that muscles are not very efficient at converting chemical energy to mechanical work done;
- apply the principle of moments to bone/muscle joints, calculate in/output forces, mechanical advantage, velocity ratio, and show how the angle between the bone and the muscle affects the forces involved;
- explain why exercise produces heat and its implications in endurance events such as marathon running.

3.7.3 Physics of Equipment and Techniques

Performance in many sports has been dramatically improved by the use of 'new materials'. New materials are expensive to develop and their first use is often in high cost/high reward applications such as defence, aerospace, medicine, Formula 1 motor sport, professional golf and tennis. Candidates need to examine the physical properties that are useful in sport materials and how they affect performance.

Many sports techniques may be analysed by applying basic physical principles.

Candidates need to:

- know the principles of conservation of energy and momentum;
- know what is meant by the coefficient of restitution;
- know the meaning of terms used to describe the physical properties of materials:
  – strength;
  – elasticity;
  – stiffness;
  – density;
  – toughness;
  – brittleness;
- describe the typical properties of:
  – metals;
  – ceramics;
  – polymers;
  – 'old' composites such as wood and leather;
- identify the purposes for which materials are needed and the conditions which they are used in sports equipment;
- explain and compare the materials using researched values of physical properties;
- explain what is meant by a composite material;
- research the use of new materials in a range of sporting applications and show why a particular material was used for a particular job and explain the advantage to the player.

Many sports events involve the interchange of kinetic energy, gravitational potential energy and elastic potential energy.

Candidates need to:

- calculate the energy and momentum involved in diverse examples of sports;
- apply conservation of energy and momentum to simple sporting examples such as the collision of snooker balls, rugby players, bats and balls;
- explain the effects of spin on the trajectory and bounce of a ball;
- explain how sails and wings produce forces for motion and lift;
- show that rotating objects have both kinetic energy and momentum, and explain how a change in shape may lead to a change in rate of rotation and apply this to various sporting examples.

3.7.4 Practical Techniques and Procedures

Candidates need to demonstrate their practical skills by planning and performing two **experimental investigations** relating to the physics of sport.

For these tasks candidates need to:

- select practical work from measurement, physics of the body,or physics of equipment and techniques;
- identify hazards and carry out a risk assessment;
- plan and follow procedures;
- make and record any observations or measurements;
- process and evaluate the results;
- carry out any relevant calculations.

3.8 A2 Unit G627: *Investigating the scientist's work*

The production of new and improved products is dependent on innovative technology and research. Research advances knowledge and technology and provides trained scientists to meet the needs of industry. Scientists are not only involved in scientific work but they also need to be able to communicate, plan and have good organisational skills. It is essential that the outcomes of any research or analytical work are accurately recorded and clearly presented.

This unit provides an opportunity to work as a research scientist, and to use the knowledge and skills that candidates have developed in previous work to complete an extended investigation into a topic which candidates can research and study in depth. It will give candidates the opportunity to increase their practical competence and organisational skills and allow them to increase their confidence to work both independently and with colleagues.

This unit extends the work covered in the AS units and gives an opportunity for synoptic assessment. It draws together the skills and knowledge from all parts of the mandatory units. There are strong links involving planning opportunities within G623: *Cells and molecules*, and involving techniques within G628: *Sampling, testing and processing*. This unit also offers the chance to build on knowledge and further investigative work from other units, both AS and A2. It can also complement A2 units in GCE Chemistry, Biology, Physics and Psychology.

Candidates will produce an information pack, which can be used and understood by a group of scientific research technicians. Candidates' evidence will include:

- a detailed and workable plan for **one** scientific vocational investigation, to include aims and objectives, full details of experimental work, and constraints under which candidates will need to work, with documented evidence of research;
- evidence to show how the plan was implemented safely;
- a record of the data collected and how it was processed and interpreted;
- an evaluative scientific report on the outcomes of the investigation suitable for technicians to understand and use.

3.8.1 Planning an Investigation

An essential skill of a working scientist is to plan and organise the work they do. Using time effectively and keeping to deadlines are important in daily work schedules. In this unit, candidates will aim to work as a research scientist, and will complete an investigation which will allow them to study, in depth, a project that brings together the skills and knowledge candidates have gained from previous units. A candidate's investigation, which needs to be related to a vocational context, needs to be carefully planned. Their plan needs to cover the whole investigation, not just the experimental work. In the workplace, teamwork forms an essential part in the efficient running of an organisation. To reflect the real work situation, teamwork can contribute towards part of their investigation, but candidates need to include their own individual evidence.

For the plan, candidates need to:

- carry out suitable research on the chosen topic;
- decide on the aim of the investigation;
- set realistic and achievable tasks (objectives);
- organise both the time availability and the use of specialist facilities;
- identify and use suitable secondary sources of information to select the relevant material;
- make suitable checks for the validity of the information chosen;
- select appropriate techniques and equipment to obtain the primary data;
- identify any constraints and their effect on what candidates can do;
- research and use the relevant health and safety regulations;
- consider any ethical implications.

3.8.2 Carrying Out the Investigation

Candidates will have the opportunity, in this part of the unit, to use their organisational and practical skills. This part of the investigation involves implementing their plan. Candidates need to follow the necessary procedures correctly and safely in order to gather sufficient primary data to allow the objectives to be achieved. Candidates need to work to the deadlines they have set and, as in a work situation, make appropriate changes or modifications to their work if they are not achieving the required outcomes. Candidates need to show they can work independently and call on colleagues if and when required. Accuracy in recording results is an important part of investigative work. Candidates need to record all relevant observations and measurements as they complete their experimental work.

Candidates need to know how to:

- carry out risk assessments and comply with health and safety regulations;
- order the required equipment to carry out the experimental procedures;
- if necessary, carry out trials to check that specific techniques or procedures will provide the data required;
- use the techniques and procedures chosen to obtain primary data (either quantitative or qualitative) accurately and reliably;
- work to deadlines set and make any changes as appropriate;
- check accuracy and reliability of data throughout the project, making any changes as required;
- record accurately the data they collect in an appropriate format (any quantitative data needs to be recorded to the required precision);
- identify the need to repeat any work or collect additional data where appropriate;
- use an appropriate sampling method to obtain a representative sample.

3.8.3 Processing and Presentation of Data from the Investigation

One of the skills of a good scientist is the ability to present the results and outcomes from experimental or research work in a clear and concise way. This work needs to be suitably presented so that it can be interpreted correctly.

The data candidates have gathered from their investigative work needs to be processed by carrying out calculations and plotting graphs, and then presented in a suitable format. Candidates need to be aware of the variety of ways this can be done so it is suitable for the audience for which it is intended.

Candidates need to know how to:

- group data to make analysis easier;
- select and use appropriate methods to process data;
- use standard methods to carry out calculations and graphical methods to display any qualitative data;
- deal with any anomalous data;
- present results in suitable and effective ways.

3.8.4 Evaluation of the Investigation

At the beginning of their investigation, candidates set both aims and objectives. Candidates now need to evaluate the results and any data they have collected and come to valid conclusions. It is important in all scientific work that the outcomes recorded are accurate and reflect what has been carried out. The outcomes are not always as expected and therefore candidates need to comment on whether the methods they used were suitable, or maybe give recommendations on what could be carried out in the future if others continued working on similar topics.

Candidates need to know how to:

- interpret the results and identify any sources of error;
- draw conclusions which are valid in relation to the data collected and to the purpose of the investigation;
- show evidence of the reliability of the data collected during the investigation;
- evaluate the methods used and if appropriate make recommendations for improvements to the investigation.

3.8.5 Presentation of the Outcomes of the Investigation

An essential skill for scientists is the ability to share their work with others. Those involved can range from other scientists with good scientific knowledge, to interested members of the public. A final part of the scientist's work is to produce a report, which evaluates to what extent the aim of the investigation has been achieved.

Candidates need to know how to:

- produce a clear and accurate report of the outcomes of the investigation which could be used and understood by research technicians (this report could be a written report, presentation poster, video or any other appropriate medium);
- set out the report in a way that is logical, well structured, concise and clear using correct spelling, punctuation and grammar;
- use scientific terminology accurately.

3.9 A2 Unit G628: *Sampling, testing and processing*

Two important areas in which scientists work are in the analysis and identification of naturally occurring materials and in the development of beneficial new products from these materials. By studying this unit candidates will understand how scientists use their knowledge to develop techniques for sampling and testing these materials.

There are many areas in which analytical scientists work. They may work in environmental organisations, in hospital laboratories or be involved in assessing the suitability of novel ceramic materials. Processing includes the making of new medicinal products, modifying polymers for new purposes or new methods for recycling scarce metals.

This unit complements G620: *Science at work*, G621: *Analysis at work* and G622: *Monitoring the activity of the human body*, and requires greater detail about the needs for sampling, testing and processing across several different areas of activity. It also supports work in G625: *Forensic science* and investigative work in G627: *Investigating the scientist's work*.

This unit draws together skills developed in both the AS and A2 units already studied and gives opportunities for synoptic assessment.

There are links in this unit to a number of NVQ framework areas involving Construction, Engineering, Manufacturing and Health and Social Care.

This unit will help candidates prepare for a higher education course as well for employment in a science-based industry.

3.9.1 Identification of the Requirements of Sampling

When samples are to be collected in a scientific way, a number of questions need to be considered:

- What is the purpose of collection?

Once candidates have answered this, then the nature of the sample needs to be taken into account.

- Is the source homogeneous or does its composition appear to vary?
- Are the samples affected by storage and, if so, how long should they be kept before they are tested?
- Should more than **one** sample be collected, and from where?
- In collecting samples, are candidates aware of possible dangers caused by weather changes or other environmental hazards?
- Once collected, which method of testing should candidates choose to obtain the best results?
- Is a modification of this method necessary?

Candidates need to:

- decide where, when and how often to take samples;
- decide how many samples to select;
- collect samples with regard to any possible hazards and to assess any risks present;
- comment on the health and safety implications of their sampling;
- select the most appropriate size of sample to take;
- choose the most appropriate way of storing the samples before testing them;
- know what to do if their sampling method does not work.

3.9.2 Obtaining Representative Samples and Correct Storage

Samples can be collected by following standard procedures or by modifying them according to circumstances. Sometimes an appropriate procedure does not exist and candidates need to use their scientific knowledge to devise the most suitable method of collection.

Once the samples have been obtained, they need to be stored in such a way that the samples do not alter on standing. This is particularly important when storing food samples but chemical samples too may alter under some conditions of temperature, humidity or light.

Candidates need to know how to:

- use an appropriate sampling method to obtain a representative sample;
- be certain that the correct conditions for sampling are observed;
- prepare and use the correct equipment for sampling;
- control the conditions when collecting so that the samples are of the optimum quality;
- store the samples under the correct conditions;
- record details of the samples selected;
- clean sampling equipment and dispose of materials in a correct way;
- ensure that safe operating procedures are followed.

3.9.3 Following a Standard Testing Procedure or Devising a Suitable Test

Once the samples have been obtained, candidates need to know which properties of the material are to be determined during the test.

This might be finding the percentage of a metal in an ore, or the electrical conductivity of an alloy or the purity of a drug being manufactured in a process. The samples then need to be prepared for sampling. This could involve crushing and making a solution for chemical analysis, or sectioning a sample for microscope work.

Once the sample is prepared, it needs to be tested, either by using or adapting a standard testing procedure, or by devising a completely new method.

Candidates need to:

- recognise the properties to be determined;
- select, adapt or devise a suitable method of testing;
- know how to prepare the samples for testing;
- know how to prepare the testing equipment for use;
- ensure that they are aware of any potential hazards that may occur during testing;
- follow the testing method in the correct order, modifying it as necessary;
- record any modifications to the normal testing method;
- accurately record the results of a test;
- know how to clean the testing equipment and dispose of materials correctly.

3.9.4 Awareness of Test Methods

Instrumental methods form an important part of modern analytical work. Candidates should have a basic awareness of the uses of the following techniques and an outline understanding of how the results obtained are interpreted.

For mass spectrometry candidates should be aware of the terms *molecular ion* and *relative molecular mass*.

Candidates need to know about

- colorimetry;
- chromatography - thin layer, gas-liquid, column and HPLC;
- infrared absorption spectroscopy;
- mass spectrometry.

3.9.5 Evaluation of the Test Results

The data obtained from the tests then need to be interpreted and the results evaluated. This can be done by calculation or by a graphical method or by presenting the results in a diagrammatic form.

Candidates need to know how to:

- present their results in the clearest way;
- process their results by the use of appropriate calculations;
- identify any unexpected results and decide what action to take;
- evaluate the accuracy, validity and reliability of the test results;
- report the significance and implications of the test results.

3.9.6 Processing in the Laboratory

New processes are tried out in the laboratory before deciding whether to proceed up to larger-scale manufacture using a pilot plant. Small-scale processing is also used to prepare small quantities of very pure materials as reference standards in analysis.

Candidates need to:

- describe techniques and procedures used to process materials and products in the laboratory;
- explain the meaning of simple scientific terms used in sampling, testing and processing. These will include the common terms used in methods of separation. Candidates will also need to know the meaning of more specialised words and phrases encountered in the case studies. Common examples include *centrifuge*, *precipitate*, *residue*, *distillate* and *placebo*.

3.9.7 Identifying or Devising a Suitable Process

The processing method that candidates are using needs to give a product in a required quantity, of a definite purity and at a reasonable cost. Health and safety is an important consideration when selecting a suitable process.

The method that candidates choose will have to be appropriate to these criteria. Candidates may find that a suitable method is already available or candidates may need to modify an existing method or even devise a new method.

Candidates need to:

- understand the purpose of small-scale processing;
- find a suitable standard processing method;
- adapt their method if the method does not work as expected;
- devise a suitable processing method if one is not available;
- identify any hazards and assess the risks of their method.

3.9.8 Carrying out Small-Scale Processing

An important part of laboratory work is to be confident when using the materials and equipment. Candidates may need to gain additional skills in the use of more specialised equipment.

To carry out small-scale processing in an effective way, candidates need a grasp of the underlying scientific ideas, as well as good manipulative skills and a careful attention to detail.

Candidates need to:

- obtain the necessary equipment and materials;
- prepare their equipment for use;
- assemble the equipment;
- produce small quantities;
- assess their product against the specification required;
- alter their procedure if any problems arise;
- clean their equipment after use and dispose of unwanted materials correctly;
- follow the health and safety guidelines for their processing method.

3.9.9 Evaluation of the Process

An important part of any procedure is its evaluation. Candidates need to evaluate the process against the starting objectives.

Candidates need to:

- see if their product fits the required specification;
- see if their process fits the requirements;
- decide if further development of their processing method is required;
- make recommendations for production on a larger scale.

3.10 A2 Unit G629: *Synthesising organic chemicals*

Many chemists work as part of a team involved in the creation and development of new and increasingly sophisticated compounds. Most of the compounds made today are organic and impact considerably on our lives. Pharmaceuticals, dyes, plastics and explosives all play an important role in today's society, and chemists are always striving to improve or create new substances in order to bring us greater social and economic benefits.

The work of the chemist may vary, from the synthetic chemist striving to discover novel molecules which can benefit our quality of life, to the analytical chemist investigating the purity of products, and finally to the process development chemist who will scale up the synthesis and assess its viability.

This unit builds on G621: *Analysis at work*, G622: *Monitoring the activity of the human body* and G624: *Chemicals for a purpose*. It can also complement A2 units in GCE Chemistry and Biology. There are also links to the NVQs in Laboratory Operations and Process Operations.

This unit will help candidates prepare for higher education courses in chemistry or other science courses with a chemical component. It will also provide candidates with some of the skills needed for working in a chemical or science-based industry.

Candidates will investigate synthesising organic chemicals. Candidates' evidence will include:

- a report or leaflet which demonstrates an understanding of organic chemistry by the correct identification and naming of functional groups, the importance of different types of isomerism and different types of reactions involving organic molecules;
- a report recording research into therapeutic drugs including their usage and mode of action in the body;
- research on a process used to manufacture an organic compound – candidates will show an understanding of the factors to be considered by a manufacturer when scaling up a small-scale process in terms of health and safety, plant design, costs and the use of automation with evidence of appropriate calculations;
- production of **two** preparations of organic compounds candidates have made and purified in the laboratory – one of which will be a useful drug– a report for each sample detailing their preparation, method of purification, percentage yield and evaluation.

3.10.1 Organic Compounds and Functional Groups

Chemical synthesis forms the foundations on which the chemical and pharmaceutical industries are built. Carbon has the unique ability to form strong chemical bonds between not only carbon atoms but also many other elements such as oxygen, hydrogen, chlorine and nitrogen. Before any synthesis is undertaken, the synthetic chemist needs to take into account **two** factors – the identity of functional groups within molecules and molecular shape. Both factors are central to the understanding of reaction pathways.

Candidates need to:

- explain why carbon forms such a huge range of compounds;
- describe organic compounds as chain, branched chain or ring;
- distinguish between aliphatic and aromatic compounds;
- recognise the following types of aliphatic compound and their functional groups:
  – alkene, >C=C<;

– alcohol, -OH;
– carbonyl, >C=O;
– carboxylic acid, -COOH;
– amine, -NH_2;
– amide, -CONHR;
– ester, -COOR;

- recognise the following types of aromatic compounds and their functional groups:
  – benzene;
  – phenols;
  – phenylamines;
  – carboxylic acids;
- name organic compounds containing the functional groups listed above;
- draw structural and displayed formulae for compounds containing the functional groups listed above and describe their 3D shape;
- identify which bonds can rotate in a molecule and describe the effect this has on its 3D shape;
- explain and give examples of structural and stereo isomerism;
- locate information about the solubility, melting points and boiling points of organic compounds.

3.10.2 Types of Chemical Reaction

Each functional group has its own characteristic set of reactions. These reactions enable the synthetic chemist to plan a synthesis that is both efficient and safe.

Candidates need to:

- recognise and give examples, by using the functional groups given in the previous section (Organic compounds and functional groups), of the following types of reaction:
  – substitution;
  – addition;
  – redox;
  – esterification;
  – hydrolysis;
  – polymerisation;
- write balanced chemical equations for the reactions listed above;
- identify reagents and conditions needed for the above reactions.

3.10.3 Manufacture and Purification of Organic Compounds

The preparation of a compound is usually first tried in the laboratory on a small scale. Several methods of preparation may be tried and the yields compared; the products then need to be analysed to determine purity. Methods often have to be adapted to combine the best features of a number of routes and the best purification methods.

Candidates need to:

- carry out risk assessments and handle substances and laboratory equipment safely;
- select and assemble, where necessary, the equipment required for carrying out reactions, including heating, cooling, mixing and purifying reaction mixtures;
- follow standard procedures to prepare and purify organic compounds;
- research different methods of preparation and purification of organic compounds;
- be aware of how to modify procedures to improve a preparation;
- separate mixtures using a variety of methods such as precipitation, crystallisation, filtration, distillation and solvent extraction;
- purify products by distillation and recrystallisation;
- determine actual yield of a preparation.

3.10.4 Determination of Yield and Purity

Chemists need to be able to assess the viability of a particular preparation; part of this process involves calculating percentage yield to determine how much of the reactants have been converted to products. Analysis of the product is then necessary to determine the success of the purification process. Finally, chemists often have to research published data with which to compare their results.

Candidates need to:

- write balanced chemical equations for their preparations;
- calculate theoretical yield and actual yield for a preparation;
- calculate quantities of reactants needed to produce a given quantity of product;
- scale a preparation up or down;
- measure melting points and boiling points accurately;
- follow standard procedures to analyse the purity and/or composition of a preparation;
- compare their experimental data with published data.

3.10.5 Therapeutic Drugs and Medicines

Drugs and medicines form an important area of organic synthesis, as they impact on our well-being. Their manufacture and sales contribute significantly to our economy. Therapeutic drugs, alongside improvements in health and hygiene, have played significant roles in the prolonging of life-expectancy.

Candidates need to:

- find out about the different types of drugs and their applications, including antibiotics, antiviral, analgesic, antihistamine, anti-hypertension, anti-inflammatory, anaesthetic;
- find out about the principles of drug action in terms of the chemical structure of a drug and receptor sites in the body;
- find out about how a drug gets into the body and its site of action;
- prepare a sample of a useful drug and assess its purity using a standard procedure.

3.10.6 Industrial Manufacture of Chemical Compounds

After a new compound has successfully been created in the laboratory, the next stage is to scale up the process to pilot plant and finally industrial production. This process involves chemists working as part of a diverse team of specialists investigating all aspects of the manufacturing and market requirements for a product.

Candidates need to find out about:

- the factors that need to be considered when scaling up a small-scale preparation to a manufacturing process;
- how manufacturing processes are monitored and controlled to ensure safe and economic control;
- the health and safety regulations that impact on the manufacturing process;
- the difference between batch and continuous processes and what judgements have to be made in deciding which is the most appropriate route;
- the use of automation in laboratory operations and in monitoring reaction conditions;
- the direct and indirect costs of production and how the selling price of the product is determined;
- issues which impact on society.

3.11 A2 Unit G630: *Materials for a purpose*

Manufacturers selecting a material for a new product need to match the physical properties of the chosen material to the requirements of the application. In addition, they need to match cost to budget and consider environmental, and health and safety issues.

In this unit, candidates will learn to select an appropriate material from available data and to support their choice with well-reasoned argument. Candidates will develop an understanding of key properties of some of the main classes of materials and how to relate those properties to the specification

During the study of this unit, candidates will undertake practical work to measure some of the physical properties they learn about.

There are strong links between this unit and units in GCE Physics

This unit will help candidates to prepare for higher education courses in applied science, especially those requiring an introduction to materials science. It builds on G624: *Chemicals for a purpose* and it complements aspects of G626: *The physics of sport*, but study of G624 and G626 is **not** a prerequisite for this unit.

Candidates will select materials for **one** specified purpose and demonstrate underlying knowledge about types and properties of materials. Candidates' evidence will include:

- a presentation or poster and accompanying notes outlining the structures of polymers, metals, ceramics or glasses, and composite materials;
- a case study describing, in detail, their selection from published data of a material for a stated purpose;
- calculations of tensile stress and strain, the Young modulus and toughness from a graph of force against extension and details of sample dimensions;
- reports on:
  - I a materials testing device/machine they have designed/developed and tested and an assessment of its effectiveness;
  - II tests to show the effect of work-hardening, annealing and tempering treatments;
  - III experiments to measure electrical conductivity or specific heat capacity.

3.11.1 Types of Materials

The properties of materials are related to their structure. This, in turn, depends on the type of atoms bonded together, the type of bonding and the conditions under which they have been made.

Candidates need to know about the structures of the following classes of materials

- polymers – addition and condensation polymers, thermoplastics and thermosetting materials, cross-lining, plasticisers and fillers;
- metals – crystal structures of pure metals and alloys, dislocations;
- ceramics and glasses – soda glass, borosilicate and lead glasses;
- composite materials – reinforced concrete, glass-fibre and carbon-fibre reinforcing.

In practice the structures of metals have imperfections. Candidates need to know about dislocations and how to test the effectiveness of the following treatments:

- work-hardening;
- annealing;
- tempering.

3.11.2 Physical Properties

It is important to know how materials behave when under tension, heated, dented or connected to a source of electricity. Modern methods of measuring the hardness of a material measure its ability to withstand indentation. Industrial testing machines include Vickers, Brinell, and Rockwell.

To help candidates to understand these properties they need to:

- design and test a materials testing device (e.g. an impact (toughness), or hardness-testing machine);
- measure the electrical conductivity of a sample of resistance wire or measure the specific heat capacity of a metal sample;
- carry out an experiment to measure how the extension of a sample varies with tension.

From a given graph of the tensile force and extension of a sample, candidates need to:

- calculate tensile stress and strain;
- obtain values of the Young modulus and tensile strength and comment on its ductility;
- relate toughness to the area under the graph.

Candidates also need to understand the following properties so that they can take them into account when selecting materials in their case study:

- density;
- hardness, including Vickers, Brinell, Rockwell and Mohs' scales;
- elastic modulus (candidates need to define the Young modulus and recognise the shear, bulk and torsional moduli);
- fracture strength σ_f (for the purposes of this course, this may be considered to be the same as ultimate tensile strength σ_u);

- toughness;
- ductility and brittleness;
- electrical conductivity and resistivity;
- thermal conductivity;
- specific heat capacity;
- thermal expansivity.

3.11.3 Identification of Objectives and Constraints

In the case study candidates are asked to select materials for a stated purpose.

The first step is to decide what their material is required to do and what properties it needs to have (objectives), and then decide whether or not it is practical to do this (constraints).

Candidates need to:

- distinguish between objectives and constraints;
- identify the objectives and constraints for a given application.

In addition to the properties of the material itself, designers take into account other constraints (external factors). Candidates will need to take into account the following according to their individual case study

- price;
- demand;
- environmental considerations;
- production costs;
- government regulations;
- quantity required;
- quality required.

3.11.4 Selection

Having identified a number of suitable materials, it is necessary to identify and select the materials that meet the project's objectives and constraints. The first stage is to draw up a shortlist of 'possibles' that meet their criteria. For example, suppose in their case study candidates were choosing materials suitable for seating in a football stadium. A candidate's shortlist might include wood, plastic, concrete and steel, but not leather or cotton covered cushions. Candidates could justify these choices by reference to their selection criteria which would probably include durability and resistance to spilled drinks. The second stage is to choose the best material from their shortlist.

In the example football stadium seating, candidates might choose plastic because it is cheap, or concrete because the fans cannot throw it onto the pitch. Either way, their choice should be for a clearly stated reason.

For their case study, candidates need to:

- research data on the properties of materials;
- draw up a shortlist of possible materials that meet the objectives and their constraints, justifying their selection;
- select the material that best meets the objectives, using data about the properties and justifying their final choice;
- suggest, using published data, at least one alternative material and give reasons for alternatives.

Practical work is not expected in this part of the unit.

3.12 A2 Unit G631: *Electrons in action*

All around us, people are using personal stereos, mobile phones and computers. These instruments would not function without batteries as a source of electrical energy. There is a huge demand for portable sources of electricity. Scientists have already designed storage batteries that provide a reliable source of electricity, and research into developing environmentally-friendly and more efficient cells is ongoing. Physical chemists and technologists investigate electrochemical reactions under different conditions as a first step in development or improvement.

An understanding of the principles of electrochemistry is necessary to carry out safe and economic industrial processes, such as the extraction and purification of important metals.

There are links to G621: *Analysis at work*, G622: *Monitoring the activity of the human body* and G624: *Chemicals for a purpose*. There are also links between this unit and AS and A2 units in GCE Chemistry and Physics.

This unit will help candidates to prepare for higher education courses in chemistry, or applied science courses with a chemical or physics element. It will also provide candidates with some skills needed for working in a science-based industry.

Candidates will conduct an investigation into the principles and applications of electrochemical changes. Candidates' evidence will include:

- a report outlining the applications of stated electrochemical changes;
- a comparison of commercial cells: non-rechargeable, rechargeable and fuel, including construction, resources, uses, sustainability, efficiency, safety and environmental issues;
- practical investigations into:
    - I the factors that can change the emf of a cell and those which have no effect;
    - II the factors that affect the efficiency of a simple laboratory experiment in which an object is copper plated.

3.12.1 Electrochemical Change

Candidates need to:

- explain redox in terms of electron transfer;
- understand what is meant by *oxidation number*;
- recognise the particles that gain or lose electrons in a chemical reaction;
- recognise changes in oxidation number;
- write ionic half equations and combine them to give equations for redox reactions;
- explain redox equilibria.

3.12.2 Principles and Applications of Commercial Cells

Chemical reactions that proceed by the complete transfer of electrons are a potential source of electricity. Scientists need to understand how the movement of the electrons can be improved and harnessed to produce an electric current. By changing the variables in simple experiments and analysing the results, scientists can develop cells that are efficient, safe and useful.

Candidates need to:

- explain the difference between a cell and a battery;
- explain the terms *half-cell* and *electrode potential*;
- use metal/metal-ion half-cells to make an electrochemical cell;
- explain the purpose of the salt bridge;
- identify the half-ion reactions that are taking place in the cell;
- define potential and potential difference;
- measure the potential difference (pd) generated by some simple electrochemical cells;
- measure the effect of changes in concentration and temperature on the pd of voltaic cells;
- explain the terms *current*, *EMF*, *terminal potential difference* and *internal resistance*;
- explain the term *standard hydrogen electrode* and describe how it is measured;
- use standard electrode potentials to calculate EMF of cells;
- explain why values of the calculated and experimental EMF may be different.

Conventional electrochemical cells are used in calculators, torches, personal stereos, computers and many other machines. There are many types advertised for sale and candidates will be able to investigate some of them.

Candidates need to:

- describe examples of primary and secondary cells and explain how they work;
- explain the difference between a primary and secondary cell.

Candidates need to carry out research on:

- the different types of batteries on the market and their uses;
- factors that need to be considered when choosing a battery;
- care and maintenance of batteries;
- the importance of recycling batteries.

3.12.3 Electrolysis and the Extraction of Metals

Electricity is a flow of electrons that can be used to perform work. In a voltaic cell a chemical reaction produces electricity. In an electrolytic cell an external source of electricity is used to produce a chemical reaction. Electrolytic cells are of considerable economic importance. Without them we would not be able to produce large amounts of important metals like aluminium and sodium.

Candidates need to:

- explain electrolysis and the terms *electrolytic cell*, *electrolyte*, *anode*, *cathode*, *anion* and *cation*;
- write redox equations for reactions that occur during electrolysis;
- use the electrochemical series to predict the preferential discharge of ions at electrodes;
- understand that the concentration of an ion and the type of electrode can affect the preferential discharge of ions;
- define the coulomb;
- calculate and measure the amount of product deposited at an electrode during electrolysis under different conditions.

There is a constant need to produce useful materials from minerals present in the Earth's crust. Thousands of tonnes of aluminium are produced annually in the U.K. which could not have been achieved before the discovery of electricity. The use of some metals like copper and tin require a high degree of purity. Even though these metals can be extracted by other methods, electrolysis is used in their purification.

Candidates need to:

- explain why some metals can only be extracted by electrolysis;
- set up a simple electrolytic cell to obtain pure copper;
- explain why there is a high demand for very pure copper.

Candidates need to find out about the electrolytic production of at least **two** metals. Candidates need to:

- give reasons for the choice of raw materials, electrolyte, electrodes;
- describe how energy costs are conserved;
- explain all chemical reactions that take place;
- describe how products and by-products are collected and stored;
- describe safety and environmental issues;
- produce calculations of the amount of electricity used for the annual production of a metal.

3.12.4 Fuel Cells.

The production of electricity using combustion of fuels is very inefficient as chemical energy is lost to the surroundings as heat energy. Research is being carried out into the development of fuel cells that convert chemical energy directly into electrical energy. By studying this section, candidates will find out how fuel cells work, the problems that scientists need to overcome and the benefits that fuel cells will bring to the community and environment.

Candidates need to:

- describe a fuel cell and explain how it works;
- identify the difference between a fuel cell and a voltaic cell;
- explain the term *energy density*.

Candidates need to find out about:

- different types of fuel cells;
- uses of fuel cells;
- the efficiency of fuel cells when compared to other types of cell;
- the availability and storage of suitable renewable fuels;
- safety and environmental issues.

Candidates need to compare fuel cells to alternatives, including electric vehicles.

3.13 A2 Unit G632: *The mind and the brain*

How does the set of mental processes we collectively refer to as 'mind' emerge from activity in the brain? Attempts to answer this question are being spear-headed by neuroscientists, cognitive scientists, psychologists and philosophers. The challenge of explaining mind and consciousness has been fuelled by the remarkable advances made in our understanding of mind and brain during the 1990s, the 'Decade of the Brain'.

Neuroscience involves the scientific study of mind and brain. The breadth of subjects studied is vast and includes consciousness, addiction, mechanisms of cognition, stress and mental illness, to name but a few. A variety of methods and techniques are employed, which vary from psychological testing and behavioural observation, to brain imaging and brain surgery. Neuroscience is currently one of the most exciting and rapidly developing areas of scientific enquiry. It is a component of many degree courses, and is a subject in which findings from molecular biology are explored alongside issues in philosophy and psychological science.

This unit builds on G620: *Science at work*, G622: *Monitoring the activity of the human body*, G623: *Cells and molecules* and G627: *Investigating the scientist's work*. There are links between this unit and the A2 units in the OCR GCE Biology and Psychology specifications.

This unit will help to prepare candidates for higher education courses in medicine, neuroscience, applied biology, psychology and philosophy, and/or for other vocational qualifications in areas including the life sciences and healthcare.

Candidates will carry out a comprehensive exploration of research methods employed in the study of mind and brain. Candidates' evidence will include:

- the production of **two** sets of fact sheets designed to raise mental-health awareness, **one** set on stress and illness and the second set on research methods employed in the study of the healthy and the damaged brain;
- an evaluation of the scientific methods and techniques used in the study of mind and brain, together with a consideration of associated ethical issues and evidence of statistical research;
- the design and safe execution of a simple experiment to investigate **one** aspect of cognitive function and an investigative case study into memory loss.

3.13.1 The Mind, Stress and Illness

The belief that mind is involved in the development of physical illness can be traced back to the earliest days of medicine and the ancient Greeks. However, research has only recently provided reliable evidence to link mental state and behaviour with certain physical illnesses such as heart disease. Moreover, the evidence linking psychological factors and development of diseases such as cancer remains poor.

Candidates need to:

- distinguish the general term 'stress' from specific emotional states such as anger;
- identify possible causes of stress;
- discuss the biological basis of the stress response, including the importance of hormones such as cortisol;
- explain physiological and psychological measurement of stress;
- consider the implications of stress in relation to physical illness;
- discuss how intervention programmes may be employed to prevent disease progression and outcome;
- research statistics for the U.K. to prepare a fact sheet identifying the frequency of different categories of stress-related mental health problems.

3.13.2 Exploration of the Healthy and the Damaged Brain

The human brain comprises thousands of millions of nerve cells, or *neurons*, and their supporting cells. These cells work in synchrony with over a thousand neurochemicals and many thousands of genes to orchestrate cognition and behaviour.

Candidates need to:

- describe how the structure and function of nerve cells varies in the brain;
- recount the passage of the nerve impulse along the neuron and the electrochemical events at the synapse, including the generation of post-synaptic potentials;
- provide examples of the receptor subtypes for dopamine and serotonin in the brain, and explain how Cocaine and Prozac work at the synaptic junction and produce their behavioural effects;
- describe the structure and functions of the following brain structures:
  – frontal lobes;
  – temporal lobes;
  – parietal lobes;
  – occipital lobes;
  – corpus callosum;
  – ventricles;
  – limbic system (including hypothalamus, hippocampus and amygdala);
  – basal ganglia;
  – brain stem;
- describe the behavioural and cognitive-effects associated with damage to the frontal lobes using Phineas Gage as an example, and explain how the brain attempts to deal with damage to itself;
- explain how genes may exert their effects on behaviour via expression in the brain;
- discuss how Alzheimer's disease and Huntington's disease affect the brain and behaviour and understand the rationale for the pharmacological treatment of Alzheimer's disease;

- explain how foetal brain-cell grafts and stem-cell technology might be used in the treatment of neurodegenerative disease;
- discuss current theories of schizophrenia; the dopamine hypothesis and the role of brain circuits in producing auditory hallucinations, genetic contributions, environmental influences, and expound the pharmacological basis of antipsychotic medication.

3.13.3 Methods and Ethical Issues in Brain Research

A knowledge of the methods and techniques employed in modern brain research, along with their advantages and limitations, is crucial to understanding and evaluating findings.

Important ethical issues inevitably arise from investigations of the brain and mind. These issues relate, not just to the methods used to study and alter brain function, but to any new knowledge about the brain acquired by these methods. Candidates need to consider some of the important ethical issues associated with brain research and its applications, which scientists and the public are now beginning to address.

Candidates need to:

- describe invasive methods (brain stimulation, lesion production, stereotaxic surgery) of investigating brain function;
- describe non-invasive methods (repeated transcranial magnetic stimulation and brain imaging techniques such as fMRI and MEG, computational modelling) of investigating brain function;
- describe experimental techniques (foetal brain-tissue grafting, stem-cell research);
- describe genetic techniques in brain research (knockout mouse models in memory research) and illustrate how these techniques can be combined with those such as fMRI above;
- discuss the ethics of brain investigation and the various techniques employed;
- consider the ethics of future technologies:
  – whether advances in medicine and biotechnology should be used to enhance cognitive and mental function;
  – whether brain scanning should be used as a screening tool or as a predictor of a tendency to behaviours such as aggression.

3.13.4 Everyday Cognition

How and why are we aware of events around us? How can we remember what we had for lunch yesterday and plan what we intend to do tomorrow? Candidates will consider fundamental elements of cognition, applications to cognitive research and patient care, and some basic practical work.

Candidates need to:

- discuss the neurobiological and molecular basis of memory, explaining the roles of synaptic plasticity and long-term potentiation in learning, along with the relative roles of cellular mechanisms such as gene activation;
- discuss elements involved in ‘eye-witness testimony’;
- carry out simple learning tests to compare different individuals’ ability to recall events;
- discuss both biological and psychological mechanisms and implications of memory loss;
- describe the cognitive assessment and neuropsychological treatment of amnesia;
- discuss research carried out in the areas of memory loss in relation to either neurological deficit or head injury;
- carry out an investigative study on memory.

3.14 A2 Unit G633: *Ecology and managing the environment*

Ecologists investigate the types and numbers of organisms in ecosystems and then try to explain why they live there. This explanation involves a consideration of the relationships of these organisms with each other and with their physical environment.

There is a very fine balance between each organism in an ecosystem and their physical environment, with each organism having its own niche – its way of life and role within the life of that community. The types and complexity of ecosystems across the world's regions contribute to the vast biodiversity of animal and plant species on the planet. As humans depend, in many ways, on plants and animals to live, it is essential to preserve this biodiversity, but the physical and biological environments affecting ecosystems undergo constant change. Some of these changes have been gradual, some dramatic. Many of these changes have increased plant and animal diversity, and have been the driving force for evolution, but some have also led to at least five mass extinctions over 500 million years.

The Earth's ecosystems and its biodiversity are studied and reviewed by ecologists, evolutionists and many other types of scientist. More than ever before, we are monitoring changes in ecosystems and, as a consequence, introducing measures to repair ecosystems and practices that make the way we exploit plant and animal species sustainable, thereby preserving biodiversity.

By studying this unit, candidates will learn about the techniques that ecologists use to study ecosystems. Candidates will develop an understanding of the relationships between the biological and physical components of ecosystems and research how these are affected by change, including the phenomenon of 'global warming'. Candidates will discuss the need for humans to maintain species diversity, review the methods which can be used to do this and evaluate **one** example of the measures that ecologists and other scientists are taking to manage an ecosystem.

This unit builds on G620: *Science at work,* G621: *Analysis at work* and G622: *Monitoring the activity of the human body*. There are strong links between this unit and G627: *Investigating the scientist's work* and AS and A2 units in GCE Biology and Geography.

This unit will help candidates to prepare for higher education courses in biology, ecology, environmental science or geography, or for work in environment-related occupations. It will also provide the background for evaluating environmental policies within employment in all industries and services.

Candidates will investigate ecology and managing ecosystems. Candidates' evidence will include:

- a knowledge and understanding of the effects of change on ecosystems and biodiversity, describing ecological selection and researching the effects of agricultural practice, human habitation and greenhouse gas production;
- a discussion of the reasons for preserving ecosystems and biodiversity, describing the methods available to do this, and carrying out a study and evaluation of the methods used to manage an ecosystem;
- a planned investigation of an ecosystem.

3.14.1 Investigation of Ecosystems

In order to understand ecosystems fully, ecologists use a range of methods to measure the physical factors that affect the ecosystem. They also have to examine and measure the biological factors that affect the ecosystem. The number and types of species in any particular place is called its biodiversity. No ecosystems exist that are made up of only **one** or just a few organisms. Within any stable ecosystem, there is a close, finely balanced relationship between the physical factors that make up an ecosystem and the organisms that live there, with each organism having its own way of life and role within the life of that community.

Candidates need to examine the range of methods ecologists use and apply them in a selected ecosystem to carry out a detailed study. Candidates then need to use their findings to try to explain the relationships between the organisms and their physical or abiotic environment.

When measuring physical factors, ecologists use techniques including chemical measurement, electronic measurement and the use of indicator species. When measuring the distribution of organisms making up the biological environment, it is not usually practical to count every organism in an ecosystem, so ecologists use sampling techniques.

Candidates need to:

- describe methods available to measure the physical factors that affect the distribution of organisms in ecosystems, including the way in which computer technology is used in ecological research;
- describe methods available to measure the distribution of organisms using appropriate sampling techniques (quadrats, sampling randomly and along a line or belt transect) and counting methods (species density, species cover) throughout the ecosystem studied;
- plan and carry out an investigation of one ecosystem, selecting and using appropriate equipment and techniques to make measurements of physical and biological factors;
- present and display data using appropriate tables and graphs;
- summarise data using the appropriate descriptive statistics (mean, standard deviation);
- manipulate data using appropriate statistics, e.g. Simpson's diversity index;
- relate the suitability of the methods used to collect data to the particular habitat and the organisms being studied;
- use the appropriate statistics, e.g. chi-squared test or t-test, to test the validity of any possible trends in data;
- form valid conclusions on the distribution of organisms based on data and statistical analysis;
- explain the relationships between the organisms in the ecosystem and their physical environment;
- evaluate the validity of the data based on the monitoring methods used.

3.14.2 Effects of Change on Ecosystems

The physical and biological factors within any ecosystem are subject to change. Organisms themselves can modify their environment. Billions of years ago, the photosynthesis of blue-green bacteria is thought to have produced all the oxygen gas present in the Earth's atmosphere. Changes that can be seen today are usually more modest and include ecological successions. Many organisms are adapted to changes that occur in their physical environment, such as seasonal changes, but events, such as volcanic eruptions, have more dramatic effects on ecosystems. In addition, in today's world, the often desperate need for human habitation, food and raw materials and the necessity for industrial processes and transport have also affected ecosystems and biodiversity.

Candidates need to:

- describe the process of succession within ecosystems;
- research and describe how agricultural practice (monoculture and hedgerow removal, use of pesticides and fertilisers) has led to changes in ecosystems and biodiversity;
- research and describe how the requirement for human habitation has affected ecosystems and biodiversity;
- research and discuss how greenhouse gas production (natural and man-made) may affect ecosystems and biodiversity.

3.14.3 Investigation of the Management of Ecosystems

Humans are dependent on the planet's biodiversity. Ecologists consider the value of this biodiversity. Plants provide organisms with the oxygen they need and act as a 'sink' for carbon dioxide, limiting its build-up from natural and human activity. Many organisms provide us with food, drugs, dyes and materials such as timber, paper and rubber. Many more may, one day, be shown to yield other products. In addition, all our crops and domestic animals have wild relatives. These may have genes that it may be useful to breed back into our domesticated species. Finally, all organisms within an ecosystem are dependent on each other. The removal of one will have effects on others.

In addition to these reasons, many scientists also see an 'intrinsic' value to species biodiversity. They value the presence of other living organisms on the planet, irrespective of economics or biology. Many people would question the right of any species to deprive another of its habitat or existence.

Our understanding of the effects of ecological change now, however, means that scientists may wish to manage world ecosystems. We can limit the build up of greenhouse gases, use bioremediation to remove toxic materials from the environment and use sustainable practices in agriculture and in the production of other resources, to help to preserve the planet's ecosystems and rich biodiversity.

Candidates need to:

- identify scientific, moral and ethical reasons for preserving biodiversity on the planet;
- evaluate the effectiveness of sustainable practices to agriculture and use of natural resources in preserving species diversity;
- evaluate how the management of designated areas (conservation areas, ecotourism, bioremediation to remove toxic material) is used to preserve ecosystems and biodiversity;
- evaluate the methods used to decrease the emission of man-made greenhouse gases (cleaner industrial production, legislation, use of recycling systems) and discuss the ways in which levels of greenhouse gases in the atmosphere could be reduced (carbon sinks);
- evaluate the methods used in the management of an ecosystem by one ecologist, a team of ecologists, a professional body, or group of scientists; candidates need to examine information and other data on the project and evaluate fully the effectiveness of the management techniques.

3.15 A2 Unit G634: *Applications of biotechnology*

Biotechnology is the use of organisms, cells and parts of cells, for instance, in recombinant DNA technology and vaccine production, for commercial, industrial and medical purposes. Few scientific subjects generate as much media interest as biotechnology and once candidates have completed this unit they will be able to separate the myth from reality.

This unit extends the knowledge and skills covered in G620: *Science at work*, G621: *Analysis at work*, G623: *Cells and molecules* and G625: *Forensic science*. There are strong links between this unit and G627: *Investigating the scientist's work* and A2 units in GCE Biology.

This unit will help to prepare candidates for higher education courses in applied biology, biochemistry or for other vocational qualifications in areas of agriculture, horticulture or biotechnology.

Candidates will investigate the use of biotechnology to solve agricultural, medical and industrial problems. Candidates' evidence will include:

- the production of a public information booklet to include information on the science of genetic engineering, and the use of recombinant DNA technology in medicine or agriculture;
- an evaluation of the effectiveness of techniques, benefits and impact on society of the production of genetically modified food plants, including evidence of associated financial calculations, consideration of the moral and ethical issues and the impact of legislation associated with the production of genetically modified food plants;
- a practical investigation into enzyme technology, to include construction of a simple bioreactor (fermenter) and the effect of temperature on enzyme activity.

3.15.1 The Science of Genetic Engineering

A lot of current research in biotechnology centres on the use of producing lengths of DNA and placing them into bacteria. These will then produce useful substances such as insulin. This technology can also be used to treat genetic diseases where a copy of the working gene is inserted into the cells of the patient. There are significant advantages to this technology.

Candidates need to understand the scientific background to recombinant DNA technology. This includes:

- the genetic code is a degenerate, non-overlapping sequence read as triplets of bases;
- proteins are synthesised inside the cell using DNA as a template;
- restriction enzymes are used to cut DNA fragments and produce sticky ends;
- DNA ligase is used as molecular glue to produce recombinant DNA strands;
- vectors such as viruses and plasmids are used to insert genes into target cells;
- the polymerase chain reaction (PCR) is used as a means of making large numbers of copies of DNA fragments;
- how electrophoresis is used in producing gene probes.

3.15.2 Use of Recombinant DNA Technology in Medicine

Much of the research that goes on in this area is novel and, at the moment, experimental. In many instances, gene technology has clear advantages over conventional methods, such as the production of insulin.

Candidates need to look at **one** specific example of how gene therapy is used to diagnose and treat genetic disorders.

Candidates need to:

- make an assessment on the effectiveness of the treatments and products (gene therapy, products such as human insulin);
- identify the moral and ethical issues that they raise (inserting foreign genes, using genetically engineered bacteria);
- describe the use of genetic probes as a means of finding genes that code for useful proteins and genetic screening for disease;
- explain the difference between germ and somatic cell gene therapy and why germ cell gene therapy is banned in many countries;
- explain the specific advantages and disadvantages to the patient of gene therapy;
- discuss whether pre-natal genetic screening should be carried out as a matter of course, who should have the information and the moral dilemmas that can arise from this;
- discuss the potential benefits and dangers of having the Human Genome mapped out for each individual from birth with respect to health management and individual rights.

None of this new technology goes on without legislation and control from government. Candidates need to look into the work of the:

- Gene Therapy Advisory Committee (GTAC);
- Advisory Committee on Genetic Testing.

3.15.3 Production of Genetically Modified (GM) Food Plants

Genetically modified plants have the capacity to do enormous amounts of good in a world that needs more and more food to feed its growing population. It could mean that food plants could be grown where it has not been possible to do so before e.g. in deserts or by the sea. Candidates need to understand the benefits to agriculture and concerns for the environment from genetically-modified plants. Candidates need to be aware of the financial implications involved in producing genetically-modified crop plants and the impact on consumer-choice.

Candidates need to:

- describe techniques used in the genetic modification of plants:
  – gene transfer using Agrobacterium;
  – gene guns;
  – marker genes;
  – regeneration of the plant;
  – checking that genes work;
  – checking for stable inheritance;
- describe the use of tissue culture or micro-propagation to produce large numbers of novel, identical plantlets;
- give **two** examples of successful genetically-modified food plants (**one** herbicide resistant and **one** insect-pest resistant);

- describe how the technology can be used to:
  – increase plant yields;
  – modify plant development or adaptation to extreme environments, e.g. tolerance to drought, salt, cold and frost;
  – reduce the use of pesticides and herbicides;
- investigate the financial aspects of GM food plant production in terms of research, development and marketing costs compared to established, non-GM food plants;
- discuss the concerns about the use of genetically modified organisms (GMOs) in food production:
  – genetic pollution (spread of genes to related organisms);
  – overuse of herbicides linked to resistant crop plants;
  – possible toxicity of pest-resistant plants to beneficial insects;
  – uncontrolled spread of GMOs to become weeds;
  – cost of seed too high for farmers from developing countries;
- list the legislative processes involved with GM foods:
  – in the UK:
  Food Safety Act, (1990);
  The Advisory Committee on Novel Foods and Processes (ACNFP);
  – in the EU:
  The Genetically Modified Organisms (Deliberate Release) Regulations, (2002).

3.15.4 Enzyme Technology

A wide variety of enzymes are used commercially as industrial catalysts. Enzymes can be used to make products cheaply and the bulk of enzymes are used in the detergent and food industry. There are some very specialised uses in the medical field. These include biosensors.

Candidates need to learn about the synthesis and action of enzymes, why they are useful in a medical, diagnostic or agricultural context and how they can be made more efficient.

Candidates need to:

- explain how enzymes work (lock and key and induced fit hypothesis for enzyme action, rates of reaction and limiting factors);
- describe how batch - and continuous-systems, including downstream processing, are used for producing large amounts of product;
- explain the techniques used in enzyme immobilisation;
- discuss the advantages and disadvantages of enzyme immobilisation;
- describe and explain how enzyme technology is applied in **one** medical or **one** agricultural context.

Candidates also need to apply their knowledge to produce a simple bioreactor (fermenter) and assess its effectiveness in producing useful chemicals in bulk.

Candidates need to:

- produce a simple bioreactor (fermenter) and investigate the effect of increased temperature on **one** chosen enzyme;
- produce an immobilised enzyme and investigate its effect on the speed and efficiency of **one** biochemical reaction;
- discuss the results of all the practical work completed;
- calculate the efficiency of the bioreactor (fermenter) used.

3.16 A2 Unit G635: *Working waves*

This unit looks at a range of applications of electromagnetic waves. Waves have always been vital tools in communication. Without them, we could neither see nor hear. Today, modern communications engineers use fibre optics, mobile phone networks and satellites to link us together as never before. Scientists, engineers and medical professionals use waves in measurement and diagnosis. Doctors also harness the energy carried by waves in applications such as therapeutic uses of γ–rays and in laser surgery. By studying this unit, candidates will be able to understand the principles involved in the use of waves for a variety of purposes in the modern world.

The content on X-ray imaging including CAT scanners is synoptic with the content of G622: *Monitoring the Activity of the Human Body*.

There are strong links between this unit and AS and A2 units in GCE Physics. This unit builds on G622: *Monitoring the activity of the human body* and complements G625: *Forensic science*.

This unit will help candidates to prepare for higher education courses in applied science or for work in communications-related occupations.

3.16.1 Waves

Candidates need to:

- describe the features common to all waves:
  - concept of displacement and its variation with time and position;
  - speed;
- describe the features common to all repeating waves:
  - speed;
  - wavelength;
  - frequency and periodic time;
  - phase;
  - amplitude;
- describe the features belonging to some waves including:
  - transverse or longitudinal displacement;
  - polarisation (including methods of polarisation of light, microwaves and radio waves);
  - sine- and square-wave shapes;
  - standing waves in pipes and strings;
  - musical notes;

  and carry out experiments on standing waves in strings and wires; be familiar with the patterns of nodes and antinodes in open and closed pipes; use these in similar calculations for wires;
- describe the features unique to electromagnetic waves;
  - changing electric field always having an associated magnetic field at right angles, hence the term *electromagnetic radiation*;
  - travel through a vacuum and discussion of effects of media (absorption scatter, slowing down);
  - produced:
    - by artificial means such as oscillating charges; high frequencies are needed to create electromagnetic radiation electronically; (radio waves were forecast by Maxwell before they could be produced);
    - naturally and artificially by excited states of nuclei, electrons in atoms, and molecules falling to lower energy levels and shedding excess energy as electromagnetic

radiation - including natural occurrences such as sunlight and radiation from uranium found in the earth;
  - hot - bodies;

- recall and use the wave equation $v = f\lambda$;
- identify the regions of the electromagnetic spectrum and describe qualitatively the similarities and differences of:
  - speed in vacuum, air and other media;
  - wavelength;
  - frequency
  - production;
  - detection;
  - uses;
  - properties, e.g. penetration of matter.

3.16.2 Thermal Imaging and other Applications of Infrared

All bodies emit electromagnetic radiation. We can see the light from the Sun or a red-hot poker with our eyes. Cooler objects emit less energy. The radiation from cooler objects will be in the infra-red (IR) region of the spectrum, which has a longer wavelength and is not visible to the eye. Infra-red radiation lies between visible light and microwaves in the electromagnetic spectrum. IR can be monitored using special detectors. Infra-red imaging is used by forensic scientists to reveal disturbed ground, by engineers to detect 'hot - spots' in machines and circuit boards, and by soldiers to see the enemy in the dark. Infra-red imaging uses the small variations in the wavelength of infra-red radiation emitted by objects at different temperatures, to reveal objects not visible to the eye.

Candidates need to:

- describe how the spectrum of 'hot-body' radiation varies with temperature (including the concept of a perfect black body);
- describe how the total radiation given off by a surface varies with temperature;
- describe how thermal imaging cameras produce images corresponding to surface temperatures;
- explain applications of thermal imaging, including:
  - electrical apparatus inspection e.g. electric circuit fault detection;
  - fire fighting and rescue e.g. detecting survivors in collapsed buildings;
  - forensic;
  - medical imaging e.g. to reveal quantitative details of circulatory problems, arthritis and rheumatism;
  - military & police target detection & acquisition, night sights, weapon systems, burglar alarms;
  - roofing inspection (especially flat roofs);
  - weather forecasting;
  - wide - area thermal mapping;
- outline the advantages of thermal detecting/imaging systems;
- understand the terms *spatial resolution* and *thermal resolution*.

3.16.3 How Optical Fibres Carry Data

The transmission of light signals along optical fibres has revolutionised telecommunications. Previously, signals were usually transmitted by electric currents in metallic conductors. The cables were bulky, ungainly and had to be amplified at frequent intervals. Scientists have developed a very pure form of glass and made this into thin fibres. By sending light along these fibres, engineers send signals without too much attenuation. Lasers can be used to emit pulsed signals which can carry enormous amounts of information. Total internal reflection prevents light from leaking through the sides of the fibres.

Candidates need to:

- explain total internal reflection and critical angle in terms of refraction at glass-air and glass-glass interfaces – candidates will be expected to relate critical angle to refractive index and wave velocity;
- explain how total internal reflection prevents light from leaking through the sides of the fibres;
- describe applications of coherent and incoherent optical fibre bundles;
- describe the construction of step-index, graded index and monomode optical fibres;
- explain why step-index fibres are coated with glass of lower refractive index;
- discuss the advantages and disadvantages of step-index, graded index and monomode optical fibres for local and long distance data transmission;
- explain how the shape of a square wave signal is degraded in multimode (multipath or step-index) fibres (diameter ~ 60μm) and how this can be overcome with graded index or monomode (single path) fibres (diameter ~ 1-10μm);
- identify the advantages of fibre-optic transmission:
  - very large information capacity;
  - low material costs;
  - small cable size;
  - negligible crosstalk;
  - high immunity to interference;
  - complete electrical isolation;
  - large repeater spacing;
- measure the refractive index of glass;
- measure the critical angle of a sample of glass and relate this to the refractive index;
- send a light signal down an optical fibre and detect it with a photodiode.

3.16.4 Modern Communication Systems – How Mobile Phones and Broadband Work

Modern communication systems such as mobile phones and broadband networks are so simple to use that a child (and even some of their grandparents!) can operate them. In this part of the unit candidates will learn about the systems which communications engineers have developed to allow many users to share the same limited bandwidth available in the form of radio waves, or down a single transmission line.

Candidates need to:

- distinguish between analogue and digital systems;
- understand binary coding;
- explain the difference between AM, FM and digital radio transmissions;
- explain Pulse Code Modulation (PCM), analogue-to-digital conversion and digital-to-analogue conversion;
- explain how broadband transmission over conventional telephone lines increases the speed of data connection to the Internet;
- explain how use of optical fibres can further increase Internet connection speeds;
- explain how multiple access (multiplexing) and cellular technologies overcome the limitation in available frequencies which prevented earlier widespread availability of mobile communications;
- explain how the splitting of a geographic area into many small cells (0.5-20 miles in radius) increases the number of users a mobile telephone network can carry and the range over which an individual user can communicate;
- discuss the factors affecting the distribution of these base stations;
- state the factors affecting mobile phone signal strength (intensity), e.g. obstructions, distance from base station (inverse-square law);
- understand the terms *up-link* and *down-link bands* as applied to mobile phones;
- compare the full duplex system used for mobile phones with half-duplex devices such as CB radios.

3.16.5 The Work of Radiologists X- and γ-Ray Imaging and Therapy

Ordinary X- and γ-ray imaging has been used as a tool by doctors and engineers for many years. Modern techniques reduce dose rates from simple images to a minimum and CAT scanners extend the information that can be obtained. Ionising radiation is normally harmful to the body, but radiotherapy deliberately uses targeted doses to treat cancer.

Candidates need to:

- state *qualitatively* the differential absorption of X-rays by air, fat, other soft tissues, bone and artificial contrast media and the appearance of X-rays on film after passing through these media;
- explain techniques for improving quality of X-ray images; the construction and use of a grid, narrow beam, filtration;
- explain how X- and γ-radiations damage cells through ionisation;
- evaluate the consequent health hazards and identify the radiological protection measures taken in X- and γ-ray imaging and radiotherapy treatment areas, to monitor and minimise the dose received by staff and the damage done to healthy tissue of patients; the half-thickness value of lead screening used;
  - the dose to staff can be reduced by:
    - reducing the size of source used;
    - increasing distance from the source (inverse-square rule);
    - reducing time of exposure;
    - inserting materials such as lead or concrete between the source and the person;
  - the dose to X-ray patients can be reduced as follows:
    - if more sensitive X-ray emulsions or image intensifying screens are used;
    - for radiotherapy patients, careful planning can reduce the dose to parts of the body not undergoing treatment;
- know the balance that needs to be struck between risk and benefit to patients when exposed to radiation as part of medical diagnosis or treatment;
- describe how the use of image-intensifying screens reduces dose rate;
- describes how digital X-ray cameras replace film by converting the energy into visible light, which is converted in turn to electrical signals that can be displayed as diagnostic images on a flat panel screen;
- describe how CAT scanners can produce much more detailed information than conventional X-rays;
- describe the structure and principles of the γ-camera used to image radioactive tracers administered to the body;
- identify the advantages of technetium-99m as a radioactive tracer;
- understand the terms *physical and biological half-life* as applied to technetium-99m tracer (calculation of overall half life from biological and physical half life data);
- describe how γ-radiation is used therapeutically.

4 Schemes of Assessment

4.1 AS GCE Scheme of Assessment

AS GCE in Applied Science (H175)	
AS Unit G620: Science at work	
33% of the total AS GCE Coursework 50 marks	This unit is assessed through portfolio work. This unit is internally assessed. **Assessment Criteria**: please refer to Appendix B at the back of this specification.
AS Unit G621: Analysis at work	
33% of the total AS GCE Coursework 50 marks	This unit is assessed through portfolio work. This unit is internally assessed. **Assessment Criteria**: please refer to Appendix B at the back of this specification.
AS Unit G622: Monitoring the activity of the human body	
33% of the total AS GCE 1 hr 30 mins written paper 90 marks	Candidates answer **all** the questions. This unit is externally assessed.

4.2 AS GCE (Double Award) Scheme of Assessment

AS GCE (Double Award) in Applied Science (H375)

AS Units G620 – G622 as above, each being 16.67% of the AS GCE (Double Award) marks. Candidates must take Unit G623 plus two of the following optional Units G624 – G626.

AS Unit G623: Cells and molecules

16.67% of the total AS GCE (Double Award) 45 mins written paper 45 marks (50%) Plan for an investigation 25 marks (50%)	This unit is externally assessed through an external, written examination (50%) and the preparation of a plan for an investigation (50%). This unit is a mandatory part of the double award only and is externally assessed.

AS Unit G624: Chemicals for a purpose

16.67% of the total AS GCE (Double Award) Coursework 50 marks	This unit is assessed through portfolio work This unit is an optional part of the double award only and is internally assessed **Assessment Criteria**: please refer to Appendix B at the back of this specification.

AS Unit G625: Forensic science

16.67% of the total AS GCE (Double Award) Coursework 50 marks	This unit is assessed through portfolio work This unit is an optional part of the double award only and is internally assessed **Assessment Criteria**: please refer to Appendix B at the back of this specification.

AS Unit G626: The physics of sport

16.67% of the total AS GCE (Double Award) Coursework 50 marks	This unit is assessed through portfolio work This unit is an optional part of the double award only and is internally assessed **Assessment Criteria**: please refer to Appendix B at the back of this specification.

4.3 Advanced GCE Scheme of Assessment

Advanced GCE in Applied Science (H575)	
AS Units G620 – G622 as above, all units being 16.67% of the Advanced GCE marks. Candidates must take Unit G627 and choose one of either Unit G628 or G635 plus one of the following optional Units G629 to G634.	
A2 Unit G627: Investigating the scientist's work	
16.67% of the total Advanced GCE Coursework 50 marks	This unit is assessed through portfolio work This unit is a mandatory part of the Advanced GCE and Advanced GCE (Double Award) and is internally assessed **Assessment Criteria**: please refer to Appendix B at the back of this specification.
A2 Unit G628: Sampling, testing and processing	
16.67% of the total Advanced GCE 1 hr 30 mins written paper 90 marks	Candidates answer **all** the questions. This unit contains some synoptic assessment and Stretch and Challenge questions. This unit is an optional part of the single award, a mandatory part of the double award and is externally assessed.
A2 Unit G629: Synthesising organic chemicals	
16.67% of the total Advanced GCE Coursework 50 marks	This unit is assessed through portfolio work This unit is an optional part of the Advanced GCE and Advanced GCE (Double Award) and is internally assessed **Assessment Criteria**: please refer to Appendix B at the back of this specification.
A2 Unit G630: Materials for a purpose	
16.67% of the total Advanced GCE Coursework 50 marks	This unit is assessed through portfolio work This unit is an optional part of the Advanced GCE and Advanced GCE (Double Award) and is internally assessed **Assessment Criteria**: please refer to Appendix B at the back of this specification.
A2 Unit G631: Electrons in action	
16.67% of the total Advanced GCE Coursework 50 marks	This unit is assessed through portfolio work This unit is an optional part of the Advanced GCE and Advanced GCE (Double Award) and is internally assessed **Assessment Criteria**: please refer to Appendix B at the back of this specification.

A2 Unit G632: The mind and the brain	
16.67% of the total Advanced GCE Coursework 50 marks	This unit is assessed through portfolio work This unit is an optional part of the Advanced GCE and Advanced GCE (Double Award) and is internally assessed **Assessment Criteria**: please refer to Appendix B at the back of this specification.
A2 Unit G633: Ecology and managing the environment	
16.67% of the total Advanced GCE Coursework 50 marks	This unit is assessed through portfolio work This unit is an optional part of the Advanced GCE and Advanced GCE (Double Award) and is internally assessed **Assessment Criteria**: please refer to Appendix B at the back of this specification.
A2 Unit G634: Applications of biotechnology	
16.67% of the total Advanced GCE Coursework 50 marks	This unit is assessed through portfolio work This unit is an optional part of the Advanced GCE and Advanced GCE (Double Award) and is internally assessed **Assessment Criteria**: please refer to Appendix B at the back of this specification.
A2 Unit G635: Working waves	
16.67% of the total Advanced GCE 1 hr 30 mins written paper 90 marks	Candidates answer **all** the questions. This unit contains some synoptic assessment and Stretch and Challenge questions. This unit is an optional part of the single award, a mandatory part of the double award and is externally assessed.

4.4 Advanced GCE (Double Award) Scheme of Assessment

Advanced GCE (Double Award) in Applied Science (H775)

AS and A2 Units as above, all units being 8.3% of the Advanced GCE (Double Award) marks. Candidates must take Units G620 – G623, G627, G628 and G635. Candidates must complete two from Units G624 – G626 plus three from Units G629 – G634 (a maximum of two from Units G632-G634 can be chosen).

For the Advanced Subsidiary GCE, **two** units will be assessed internally, through a teacher-assessed portfolio and **one** unit will be assessed externally with the assessment set and marked by OCR. These **three** units will be equally sized and equally weighted.

For the Advanced Subsidiary GCE (Double Award) and the Advanced GCE, **four** units will be assessed internally, through a teacher-assessed portfolio and **two** units will be assessed externally with the assessment set and marked by OCR. These **six** units will be equally sized and equally weighted.

For the Advanced GCE (Double Award), **eight** units will be assessed internally, through a teacher-assessed portfolio and **four** units will be assessed externally with the assessment set and marked by OCR. These **twelve** units will be equally sized and equally weighted.

The assessment will be conducted in accordance with the GCE Code of Practice.

4.5 External Assessment

External assessment forms 33% of each qualification:

Advanced Subsidiary GCE:	Candidates take **one** unit of external assessment.
Advanced Subsidiary GCE (Double Award):	Candidates take **two** units of external assessment.
Advanced GCE:	Candidates take **two** units of external assessment.
Advanced GCE (Double Award):	Candidates take **four** units of external assessment.

External assessments are 90 minutes except for G623: *Cells and molecules* which is 45 mins. G623: *Cells and molecules* has a planning task and G628: *Sampling, testing and processing* has pre-released case-study material which will be available to centres (once they have made their *provisional* candidate entries) approximately **six** weeks prior to the examination dates.

The externally assessed units will be marked by OCR. The maximum raw score will be stated on the front cover of the question paper.

4.6 Portfolio Assessment

Internal assessment forms 67% of each qualification. Internally assessed units take the form of a portfolio of work designed to enable the candidate to demonstrate understanding of the content of the unit. Each internal assessment is set by the centre to OCR guidelines, is internally marked and externally moderated by OCR.

4.7 Unit Order

Units may be taken in any order, though centres are strongly advised to cover AS Units G620, G621 and G622 early in the course, since they form a core on which other units are based.

AS units are designed to be taught and assessed in the first year of a two year course and A2 units are designed to be studied and assessed in the second year although centres should use their own discretion to create a delivery pattern that suits their particular circumstances.

Details are provided within each unit of any dependencies or advised progression routes.

Centres should also ensure all authentication documentation for every candidate is completed and kept securely with the work until moderation takes place.

4.8 Unit Options (at AS/A2)

There are no optional units in the AS GCE specification; for AS GCE in Applied Science candidates must take AS Units G620, G621 and G622.

There are optional units in the AS GCE (Double Award) specification; for AS GCE (Double Award) in Applied Science candidates must take AS Units G620, G621, G622 and G623, and choose two units from AS Units G624 – G626.

There are optional units in the Advanced GCE specification; for Advanced GCE in Applied Science candidates take AS Units G620, G621, G622 and A2 Unit G627 *and* one of A2 Units G628 or G635 plus one unit from A2 Units G629 - G634.

There are optional units in the Advanced GCE (Double Award) specification; for Advanced GCE (Double Award) in Applied Science candidates must take AS Units G620, G621, G622 and G623 *and* A2 Units G627, G628 and G635. Candidates also choose two units from AS Units G624 – G626, plus three units from A2 Units G629, G630, G631, G632*, G633* and G634*.

**(maximum of two of these units can be chosen)*

4.9 Synoptic Assessment (A Level GCE)

Synoptic assessment at Advanced GCE is designed to ensure that candidates have a good understanding of the subject as a whole and are able to address issues within the subject from a range of perspectives and in an integrated way. The emphasis is on strategic understanding and on the ability to draw evidence together from any relevant areas of the specifications. Assessment focuses on the breadth, depth and quality of candidates' analysis and evaluation. Synoptic assessment will be drawn from across the specifications.

It is expected that candidates completing portfolio work for later units will draw upon their knowledge, understanding and skills gained in earlier units, as advised within the units concerned. Synoptic assessment will involve candidates bringing together, and making connections between, the areas of skills, knowledge and understanding covered within the specifications and applying this when carrying out the substantive investigation.

4.10 Assessment Availability

There is one examination series each year in June.

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

4.11 Assessment Objectives

Candidates for these qualifications will be expected to demonstrate the following in a range of appropriate vocationally-related contexts:

AO1 Demonstration of knowledge and understanding

Candidates demonstrate their knowledge and understanding by:

- recognising and recalling facts, terminology, principles, concepts and practical techniques;
- selecting, organising and presenting, clearly and logically, information either provided or acquired through systematic research.

AO2 Application of skills, knowledge and understanding

Candidates apply their skills, knowledge and understanding in appropriate vocational contexts:

- by describing, explaining, interpreting and evaluating information and the impact on society of the work of scientists, including beneficial effects and the need for constraints;
- in carrying out relevant calculations.

AO3 Experimentation and investigation

Candidates:

- carry out safely and skilfully practical tasks, making and recording observations and measurements with appropriate precision, processing them appropriately and communicating this information clearly and logically, e.g. in prose, tables and graphs;
- plan, carry out and evaluate investigative work.

The assessment objectives are weighted as follows:

	AS Units	A2 Units	GCE and GCE (Double Award)
AO1	35-50%	15-30%	25-40%
AO2	10-25%	25-35%	15-30%
AO3	25-40%	35-50%	30-45%

4.12 AO weightings

The relationship between assessment objectives and the units of assessment is shown in the grids below.

AO weightings in AS GCE

Unit of Assessment	Mandatory or Optional	Level	Percentages of AS GCE			Total
			AO1	AO2	AO3	
G620	m	AS	38	20	42	100
G621	m	AS	38	20	42	100
G622	m	AS	64	36	-	100
		Total	**140**	**76**	**84**	**300**

AO weightings in AS GCE (Double Award)

Unit of Assessment	Mandatory or Optional	Level	Percentage of AS GCE (Double Award)			Total
			AO1	AO2	AO3	
G620	m	AS	38	20	42	100
G621	m	AS	38	20	42	100
G622	m	AS	64	36	-	100
G623	m	AS	16	34	50	100
One of G624-G626	o	AS	42	20	38	100
One of G624-G626	o	AS	42	20	38	100
		Total	**240**	**150**	**210**	**600**

AO weightings in Advanced GCE

Unit of Assessment	Mandatory or Optional	Level	Percentage of GCE			Total
			AO1	AO2	AO3	
G620	m	AS	38	20	42	100
G621	m	AS	38	20	42	100
G622	m	AS	64	36	-	100
G627	m	A2	20	28	52	100
G628 or G635	o	A2	50	50	-	100
One of G629-G634	o	A2	20	28	52	100
		Total	**230**	**182**	**188**	**600**

AO weightings in Advanced GCE (Double Award)

Unit of Assessment	Mandatory or Optional	Level	Percentage of GCE (Double Award)			Total
			AO1	AO2	AO3	
G620	m	AS	38	20	42	100
G621	m	AS	38	20	42	100
G622	m	AS	64	36	-	100
G623	m	AS	16	34	50	100
One of G624-G626	o	AS	42	20	38	100
One of G624-G626	o	AS	42	20	38	100
G627	m	A2	20	28	52	100
G628	m	A2	50	50	-	100
One of G629-G634	o	A2	20	28	52	100
One of G629-G634	o	A2	20	28	52	100
One of G629-G634	o	A2	20	28	52	100
G635	m	A2	50	50	-	100
		Total	**420**	**362**	**418**	**1200**

4.13 Quality of Written Communication

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

Candidates will:

- Ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
- Select and use a form and style of writing appropriate to purpose and to complex subject matter
- Organise information clearly and coherently, using specialist vocabulary when appropriate.

5 Technical Information

5.1 Making Unit Entries

Please note that centres must be registered with OCR in order to make any entries, including estimated entries. It is recommended that centres apply to OCR to become a registered centre well in advance of making their first entries. Final entries for units (including internally assessed units) are made in March for June units. It is important that entries are received by the deadline date – late entries cause major problems for OCR and attract a substantial late entry fee to reflect this. Centres must have made an entry for a unit in order for OCR to supply the appropriate forms or moderator details for coursework.

It is essential that unit entry codes are quoted in all correspondence with OCR. See Sections 4.1 – 4.4 for these unit entry codes.

To enter for certification, candidates must have a valid combination of unencashed units for that qualification.

Unit Entry code	Component code	Unit titles
G620	01	Science at work
G621	01	Analysis at work
G622	01	Monitoring the activity of the human body
G623	01	Cells and molecules
G624	01	Chemicals for a purpose
G625	01	Forensic science
G626	01	The physics of sport
G627	01	Investigating the scientist's work
G628	01	Sampling, testing and processing
G629	01	Synthesising organic chemicals
G630	01	Materials for a purpose
G631	01	Electrons in action
G632	01	The mind and the brain
G633	01	Ecology and managing the environment
G634	01	Applications of biotechnology
G635	01	Working waves

5.2 Making Qualification Entries

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

Candidates may enter for:

- AS GCE certification (H175)
- AS GCE (Double Award) certification (H375)
- Advanced GCE certification (H575)
- Advanced GCE (Double Award) certification (H775)

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

Candidates following a course over a number of examination series have a variety of options open to them that allow them to certificate part-way through their course. All three- and six-unit qualifications are automatically 'banked' by OCR to enable the candidate to use them towards larger qualifications at a later date.

Candidates may enter for:

- Advanced Subsidiary GCE aggregation;
- Advanced Subsidiary GCE aggregation, bank the result, and complete the Advanced Subsidiary GCE (Double Award) assessment at a later date;
- Advanced Subsidiary GCE aggregation, bank the result, and complete the A2 assessment at a later date for either an Advanced GCE or an Advanced GCE (Double Award);
- Advanced Subsidiary GCE (Double Award) aggregation;
- Advanced Subsidiary GCE (Double Award) aggregation, bank the result, and complete the A2 assessment at a later date for either an Advanced GCE or an Advanced GCE (Double Award);
- Advanced GCE aggregation;
- Advanced GCE aggregation, bank the result, and complete the Advanced GCE (Double Award) assessment at a later date;
- Advanced GCE (Double Award) aggregation.

Candidates must enter the appropriate Advanced Subsidiary units to qualify for the Advanced Subsidiary (Single or Double Award) GCE.

Candidates must enter the appropriate AS and A2 units to qualify for the Advanced (Single or Double Award) GCE.

These specifications will be shown on the certificate as:

OCR Advanced Subsidiary GCE in Applied Science.
OCR Advanced Subsidiary GCE in Applied Science (Double Award).
OCR Advanced GCE in Applied Science.
OCR Advanced GCE in Applied Science (Double Award).

AS GCE certification is available from June 2014.

Advanced GCE certification is available from June 2014.

5.3 Issue of Results

Individual unit Statements of Results will be issued in August for June entries for all units (both portfolio units and external units). Statements of Results will include, for each unit, the unit title, the unit UMS mark, the grade and the date the unit was taken.

Certification is **not** an automatic process, since OCR is unable to determine at which point a candidate wishes to complete their course. Candidates **must** be entered for the appropriate certification code (see Section 5.2) to claim their overall grade.

Entry for unit will *not* generate a final certificate – a separate certification entry must be made at the appropriate time. If it is not, there will be a delay in issuing the candidate's final grade.

5.4 Grading

All GCE units are awarded A to E. The Advanced Subsidiary GCE is awarded on the scale A to E. The Advanced GCE is awarded on the scale A to E with access to an A*. To be awarded an A*, candidates will need to achieve a grade A on their full A Level qualification and an A* on the aggregate of their A2 units. Grades are reported on certificates. Results for candidates who fail to achieve the minimum grade (E or e) will be recorded as *unclassified* (U or u) and this is **not** certificated.

A Uniform Mark Scale (UMS) enables aggregation of candidates' best performances across units and across series to determine the qualification grade. The three-unit AS GCE has a total of 300 *uniform* marks and the six-unit Advanced Subsidiary (Double Award) GCE has a total of 600 *uniform* marks. The six-unit Advanced GCE has a total of 600 *uniform* marks and the twelve-unit Advanced (Double Award) GCE has a total of 1200 *uniform* marks.

OCR converts the candidate's *raw* mark for each unit to a *uniform* mark. The maximum *uniform* mark for any unit depends on that unit's weighting in the specification. In these Applied Science specifications, all the units have equal UMS weightings with a *uniform* mark total of 100 for each unit. Each unit's *raw* mark grade boundary equates to the *uniform* mark boundary at the same grade. Intermediate marks are converted on a pro-rata basis.

Uniform marks correspond to *unit* grades as follows:

(Advanced GCE) Unit Weighting	Maximum Unit Uniform Mark	Unit Grade					
		a	b	c	d	e	u
16.67%	100	100-80	79-70	69-60	59-50	49-40	39-0

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

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

Qualification	Qualification Grade									
	AA	AB	BB	BC	CC	CD	DD	DE	EE	U
AS GCE (Double Award)	600-480	479-450	449-420	419-390	389-360	359-330	329-300	299-270	269-240	239-0
Advanced GCE (Double Award)	1200-960	959-900	899-840	839-780	779-720	719-660	659-600	599-540	539-480	479-0

Candidates who fail to achieve the standard for a grade EE will be awarded a Uniform Mark in the range 0-239 for the Advanced Subsidiary GCE (Double Award) and 0-479 for the Advanced GCE (Double Award) and will be recorded as U (unclassified). This does not lead to a certificate.

5.5 Enquiries about Results

Under certain circumstances, a centre may wish to query the result issued to one or more candidates. Enquiries about Results for GCSE units must be made immediately following the series in which the relevant unit was taken (by the Enquiries about Results deadline).

Please refer to the *JCQ Post-Results Services* booklet and the *OCR Admin Guide* for further guidance about action on the release of results. Copies of the latest versions of these documents can be obtained from the OCR website.

5.6 Shelf-Life of Units

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

5.7 Unit and Qualification Re-sits

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

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

5.8 Guided Learning Hours

Each unit requires 60 guided learning hours.

AS GCE in Applied Science requires **180** guided learning hours in total.
AS GCE in Applied Science (Double Award) requires **360** guided learning hours in total.

Advanced GCE in Applied Science requires **360** guided learning hours in total.
Advanced GCE in Applied Science (Double Award) requires **720** guided learning hours in total.

5.9 Code of Practice/Subject Criteria/Common Criteria Requirements

These specifications comply in all respects with the current *GCSE, GCE and AEA Code of Practice 2005/6*, the subject criteria for GCE in Applied Science and *The Statutory Regulation of External Qualifications 2004*.

5.10 Disability Discrimination Act Information Relating to this Specification

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

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

Reasonable adjustments are made for disabled candidates in order to enable them to access the assessments and to demonstrate what they know and can do. For this reason, very few candidates will have a complete barrier to the assessment. Information on reasonable adjustments is found in *Access Arrangements, Reasonable Adjustments and Special Consideration* produced by the Joint Council www.jcq.org.uk.

Candidates who are unable to access part of the assessment, even after exploring all possibilities through reasonable adjustments, may still be able to receive an award based on the parts of the assessment they have taken. However, as this specification tests practical skills required in a vocational context, some candidates with visual or physical difficulties may encounter difficulties.

5.11 Arrangements for Candidates with Particular Requirements

For candidates who are unable to complete the full assessment or whose performance may be adversely affected through no fault of their own, teachers should consult the *Access Arrangements, Reasonable Adjustments and Special Consideration*. In such cases advice should be sought from OCR as early as possible during the course.

5.12 Classification Code

Every specification is assigned to a national classification code indicating the subject area to which it belongs. The classification code for these specifications is 0008.

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

Centres may wish to advise candidates that, if they take two specifications with the same classification code, schools and colleges are very likely to take the view that they have achieved only one of the two GCEs. The same view may be taken if candidates take two GCE specifications that have different classification codes but have significant overlap of content. Candidates who have any doubts about their subject combinations should seek advice, for example from their centre or the institution to which they wish to progress.

6 Coursework Administration/Regulations

6.1 Supervision and Authentication

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

OCR expects teachers to supervise and guide candidates who are producing portfolios. The degree of teacher guidance in candidates' work will vary according to the kind of work being undertaken. However, it should be remembered that candidates are required to reach their own judgements and conclusions.

When supervising candidates, teachers are expected to:

- Offer candidates advice about how best to approach their tasks
- Exercise continuing supervision of work in order to monitor progress and to prevent plagiarism
- Ensure that the work is completed in accordance with the specification requirements and can be assessed in accordance with the specified marking criteria and procedures.

Work on portfolios may be undertaken outside the centre and in the course of normal curriculum time. As with all internally assessed work, the teacher must be satisfied that the work submitted for assessment is the candidate's own work. This does not prevent groups of candidates working together in the initial stages, but it is important to ensure that the individual work of a candidate is clearly identified separately from that of any group in which they work.

Throughout the course, the teacher should encourage the candidate to focus on achieving the criteria listed in the *Assessment Evidence Grids.*

Once the mark for the unit portfolio has been submitted to OCR, no further work may take place. However, the portfolio can be improved and resubmitted under the re-sit rule (Section 5.7)

Teachers may comment on a candidate's unit portfolio and return it for redrafting without limit until the deadline for the submission of marks to OCR.

Teachers must record details of any assistance given and this must be taken into account when assessing candidates' work.

Teachers must complete and sign the ***Centre Authentication Form*** to confirm that the work submitted for moderation was produced by the candidates concerned. Once completed this form must be sent to the moderator along with candidates' work.

6.2 Avoiding Plagiarism

Plagiarism in coursework is the equivalent of cheating in written examinations.

Candidates should be taught how to present material taken directly from other sources and must observe the following when producing portfolios:

- Any copied material must be suitably acknowledged
- Quotations must be clearly marked and a reference provided wherever possible.

6.3 Submitting marks to OCR

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

Teachers may set internal deadlines for candidates submitting work to them. However, should candidates fail to meet this deadline, they may only be penalised if they fail to achieve one or more of the criteria in the *Assessment Evidence* Grid for that unit. A candidate whose work is submitted so late that the teacher is unable to meet OCR's deadline for receipt of marks should be warned by the teacher that failure to submit marks by this deadline may result in OCR failing to issue grades on the agreed date. OCR will supply centres with MS1 Internal Assessment Mark Sheets to record the marks and instructions for completion. It is essential that centres send the top copy of these completed forms to OCR, the second copy to the Moderator and keep the third copy for their own records.

The deadlines for the receipt of coursework marks are published on the OCR website.

The awarding body must require centres to obtain from each candidate a signed declaration that authenticates the coursework they produce as their own. For regulations governing coursework, centres should consult the OCR *Admin Guide: 14- 19 Qualifications.* Further copies of the coursework administration documents are available on the OCR website (www.ocr.org.uk).

6.4 The Assessment Evidence Grids

Centres are required to carry out internal assessment of portfolios using the *Assessment Evidence Grids* in accordance with OCR procedures. Candidates' marks are recorded on these grids. **One** grid should be completed for each candidate's **unit** portfolio. The information on each of these grids should eventually be transferred onto a *Unit Recording Sheet* and attached to the front of the candidate's portfolio for the unit for inspection by the Moderator when the moderation process takes place.

When candidates are given their assignments, they should also be issued with a reference copy of the appropriate *Assessment Evidence Grid*.

Candidates' portfolios must be clearly annotated to demonstrate where, and to what level, criteria have been achieved. This will help in the moderation process. On completion of a unit, the teacher must complete the *Assessment Evidence Grid* and award a mark out of **50** for the unit.

6.5 Standardisation and Moderation

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

Internal standardisation can be done in a number of ways. In the first year, reference material and OCR training meetings will provide a basis for centres' own standardisation. In subsequent years, this, or centres' own archive material, may be used. Centres are advised to hold a preliminary meeting of staff involved to compare standards through cross-marking a small sample of work.

After most marking has been completed, a further meeting at which work is exchanged and discussed will enable final adjustments to be made.

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

Work submitted for moderation must be marked with the:

- Centre number
- Centre name
- Candidate number
- Candidate name
- Specification code and title
- Unit code.

For each (portfolio) unit, centres must complete the appropriate *Unit Recording Sheet* sent out annually by OCR and downloadable from the OCR website (www.ocr.org.uk).

Work submitted on paper for moderation or marking must be secured by treasury tags. Work submitted in digital format (CD or online) must be in a suitable file structure as detailed in Appendix C.

6.6 Centre Accreditation

If your centre demonstrates accurate marking of internally assessed units, your centre may be offered accredited status (by specification and level). This means that there is **no** requirement to submit work for moderation for those specifications.

Eligibility for accreditation is offered to a Programme Leader (nominated by the centre), who is responsible for the standardisation of internal assessment and must be personally involved in the assessment of candidates' work.

In each examination series, a number of accredited centres will be randomly selected for moderation as part of the control procedure. Every accredited centre will be 'sampled' at least once in every period of accreditation.

The standard accreditation period lasts for the remainder of the academic year in which it is granted and the following two academic years although the period of accreditation may be altered on the basis of the results of the random sampling. Centres will be informed of any changes to their accreditation status before each series.

Centres must ensure that:

- The Head of Centre provides the Programme Leader details and initially accepts accreditation for each level
- OCR is informed if the Programme Leader leaves the post or their responsibilities change with respect to the specification(s)
- All marks are submitted to OCR by the published deadlines
- Centre Authentication forms for accredited units with entries are completed and submitted to OCR Data Capture each series.

However, centres must have work available in case they receive requests for work required for awarding purposes.

6.7 Minimum Coursework Required

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

6.8 Instructions for Marking

Sources of Guidance

The starting point in assessing portfolios is the *Assessment Evidence Grid* within each unit. These contain levels of criteria for the skills, knowledge and understanding that the candidate is required to demonstrate. The *Guidance for Teachers* within the unit expands on these criteria and clarifies the level of achievement the assessor should be looking for when awarding marks.

OCR will hold training meetings on portfolio assessment led by senior GCE moderators. Details of these are in the OCR INSET booklets which are sent to centres in the summer term or they may be obtained from the Training and Customer Support Division (tel. 01223 552950). They are also published on the OCR website (www.ocr.org.uk).

OCR also operates a network of Portfolio Consultants. Centres can obtain advice on assessment of portfolios from an OCR Portfolio Consultant. These are both subject specialists and senior moderators. Details may be obtained from the OCR Qualification Manager.

Determining a Candidate's Mark

It must be stressed that teachers determine only the *mark* for a candidate's portfolio evidence and not the *grade* which will be determined by OCR.

Regular, early and constructive feedback to candidates on their performance is essential and crucial. Help with planning and structuring their portfolio work in a logical manner throughout the course will lead to better understanding of their work and is likely to achieve higher grades.

Giving candidates deadlines for the completion of various sections of their work, and encouraging them to adhere to them, is also essential if candidates are not going to rush to complete and possibly finish up with grades below their potential.

Each portfolio should be marked by the teacher according to the assessment objectives and content requirements in the *Assessment Evidence Grid* within each portfolio unit (a sample of which follows).

Each row in the *grid* comprises a strand showing the development of an assessment objective, each row corresponding to an assessment objective descriptor in the banner (the top section of the *grid*).

The maximum mark for each strand is shown in the far right hand column of the *grid* and this maximum mark is further broken down into a number of mark bands across each row with a range of descriptors.

Teachers use their professional judgement to determine which descriptor in a strand best suits the candidate's work and from the range of marks available within that particular mark band, they circle the mark that best fits the work. They then record this mark in the column headed *Mark.*

Teachers should use the full range of marks available to them. Teachers must award full marks in any strand of work which fully meets the criteria. This is work which is the best one could expect from candidates working at AS or A2 level.

However, for strands which include a quantified element, e.g. **two** care workers or **four** therapies, and where a candidate's evidence includes less than the number specified, or includes the correct number but at varying levels of quality, teachers will use their professional judgement to allocate an appropriate mark. It is the *quality* of the evidence that is paramount rather than the *quantity*, although, in such circumstances, candidates will be unable to access the highest mark band for that strand.

Only **one** mark per strand/row will be entered. The final mark for the candidate is out of a total of **50** and is found by totalling the marks for each strand.

6.9 Administering Portfolio Assessment and Moderation

Portfolio units are internally assessed by centres and externally moderated by OCR. There are **three** key points in the administrative cycle that require action by the teacher:

- The centre enters candidates who wish to submit portfolios (March for June examinations)
- The centre sends OCR and the moderator a set of provisional marks by a set deadline.
- The moderator contacts the centre on receipt of marks and asks for a sample of work.

OCR will conduct all administration of the GCE through the Examination Officer at the centre. Teachers are strongly advised to liaise with their Examination Officer to ensure that they are aware of key dates in the administrative cycle.

Assessment-recording materials and full details of administrative arrangements for portfolio assessment, will be forwarded to Examination Officers, following receipt of provisional entries. At the same time the materials will be made available within *Portfolio Assessment Packs* and on the OCR website (www.ocr.org.uk). The materials will include master copies of mandatory *Unit Recording Sheets* on which to transfer their assessments from each candidate's *Assessment Evidence Grids*. Forms may be photocopied and used as required.

7 Other Specification Issues

7.1 Overlap with other Qualifications

7.1.1 Relationship to other GCEs

The units of these qualifications have significant overlap of content with other OCR GCEs in the sciences. A full mapping is available from the Science, Technology and Maths Council.

7.1.2 Relationship to NVQs

These specifications introduce the candidate to skills relevant to a range of science-related NVQs, though the assessment methods are not designed to guarantee occupational competence. However, this qualification will support candidates working towards National Occupational Standards, detailed guidance for which was issued by QCA in early 2002.

In particular, there are links to units from the Laboratory and Associated Technical Activities (LATA) standards that form the basis of NVQs in the science area. Examples of these NVQs include: Laboratory Operations; Process Operations; Laboratory Technicians Working in Education.

7.2 Progression from these Qualifications

These specifications are designed to give a broad introduction to this sector and aim to prepare candidates for further study in higher education or further training which might be whilst in employment. However, these qualifications are not designed for candidates' direct entry into employment.

Candidates who achieve these qualifications may be prepared to enter a variety of HND or degree level courses in science-related subjects.

7.3 Key Skills Mapping

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

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

Unit	C2				C3				AoN2			AoN3			ICT2			ICT3			WwO2			WwO3			IoLP2			IoLP3			PS2			PS3			Unit
	.1a	.1b	.2	.3	.1a	.1b	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	
G620				P				P	P	P	P	P	P	P	P	P	P				P	P	P															G620
G621				P				P	P	P	P	P	P	P	P	P	P										P	P	P	F	F	F							G621
G624				P				P	P	P	P	P	P	P	P	P	P										P	P	P	F	F	F							G624
G625	F			P				P	P	P	P	P	P	P	P	P	P	P	P	P							P	P	P	F	F	F							G625
G626				P				P	P	P	P	P	P	P	P	P	P	P	P	P																			G626
G627				P				P	P	P	P	P	P	P	P	P	P	P	P	P													P	P	P	F	F	F	G627
G629				P				P	P	P	P	P	P	P	P	P	P													F	F	F							G629
G630				P				P	F	F	F	F	F	F	P	P	P																						G630
G631			F				F		P	P	P	P	P	P	P	P	P																						G631
G632		F				F		F	P	P	P				P	P	P										P	P	P	F	F	F							G632
G633									P	P	P				P		P										P	P	P	F	F	F							G633
G634			F	P			F	P	P	P	P	P	P	P	P	P	P																P	P	P	F	F	F	G634
Unit	.1a	.1b	.2	.3	.1a	.1b	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	Unit
	C2				C3				AoN2			AoN3			ICT2			ICT3			WwO2			WwO3			IoLP2			IoLP3			PS2			PS3			

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

Applied Science offers a range of opportunities for the exploration of spiritual, moral, ethical, social and cultural issues.

For example*:*

- the importance to the community of organisations that use science is covered in detail in G620*: Science at work*;
- the ethical and social issues connected with genetic engineering are integral to G634: *Applications of biotechnology;*
- issues affecting society, which are often perceived as being of scientific origin, are explored in many units, e.g. pollution in G633: *Ecology and managing the environment;*
- these specifications include many examples of the endeavour of scientists in applying their knowledge to the benefit of society, e.g. the use of new materials in G630: *Materials for a purpose*;
- the culture of science-based learning is explored throughout these specifications, but in particular in G627: *Investigating the scientist's work;*
- it is hoped that a sense of awe and wonder at the scale and impact of natural processes and phenomena is engendered by a study of these specifications.

Legal issues are addressed in each unit, where appropriate.

7.5 Sustainable Development, Health and Safety Considerations and European Developments

OCR has taken account of the 1988 Resolution of the Council of the European Community and the Report *Environmental Responsibility: An Agenda for Further and Higher Education*, 1993 in preparing this specification and associated specimen assessments.

For example:

- there are opportunities to study environmental issues in depth in G633: Ecology and managing the environment

OCR has taken account of the 1988 Resolution of the Council of the European Community in preparing this specification and associated specimen assessments. European examples should be used where appropriate in the delivery of the subject content. Relevant European legislation is identified within the specification where applicable.

The application of science is a global activity. Many science-based industries are multi-national, operating from bases across Europe and other parts of the world. European health and safety legislation and regulations concerning environmental issues affect the work of scientists.

Teachers are expected to take appropriate opportunities to consider issues in the European context.

Candidates are introduced to health and safety issues in the context of this sector and should be made aware of the significance of safe working practices.

For example:

- the importance of health and safety in organisations that use science is integral to G620*: Science at work;*
- the uses of therapeutic drugs and medicines are covered in G629: *Synthesising organic compounds;*
- the use of imaging techniques in medical diagnosis is covered in G635: *Working waves;*
- the use of genetic engineering in medicine is covered in G634: *Applications of biotechnology.*

7.6 Avoidance of Bias

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

7.7 Language

These specifications and associated assessment materials are in English only.

7.8 Status in Wales and Northern Ireland

This specification has been approved by DCELLS for use by centres in Wales and by CCEA for use by centres in Northern Ireland.

Candidates in Wales or Northern Ireland should not be disadvantaged by terms, legislation or aspects of government that are different from those in England. Where such situations might occur, including in the external assessment, the terms used have been selected as neutral, so that candidates may apply whatever is appropriate to their own situation.

7.9 Citizenship

This section offers guidance on opportunities for delivering knowledge, skills and understanding of citizenship issues during the course.

By taking courses based on these specifications, candidates will develop their 'scientific literacy' such that they are able to make informed decisions as citizens about the issues of the day wherever they meet them – in the workplace, the media, the home etc.

For example:

- a study of the work of people in organisations that use science as part of G630: *Science at work.*

Appendix A: Performance Descriptions

Performance descriptions have been created for all GCE subjects. The performance descriptions for GCE in Applied Science aim to describe learning outcomes and levels of attainment likely to be shown by a representative candidate performing at the A/B and E/U boundaries for the AS and A2. They illustrate the expectations at these boundaries for the AS and A2 as a whole; they have not been written at a specification or unit level. Each performance description is aligned to **one** assessment objective. An alphabetical system has been used to denote each element of a performance description. There is no hierarchy of elements.

Performance descriptions are designed to assist examiners in exercising their professional judgement at awarding meetings where the grade A/B and E/U boundaries will be set by examiners using professional judgement. This judgement will reflect the quality of the candidates' work, informed by the available technical and statistical evidence. Performance descriptions will be reviewed continually and updated where necessary.

Teachers may find performance descriptions useful in understanding candidates' performance across qualifications as a whole but should use the marking criteria identified in the specification when assessing candidates' work.

	Assessment Objective 1	Assessment Objective 2	Assessment Objective 3	Quality of Written Communication
Assessment Objectives for both AS GCE and Advanced GCE	Candidates demonstrate relevant knowledge and understanding by: • recognising and recalling facts, terminology, principles, concepts and practical techniques; • selecting, organising and presenting, clearly and logically, information either provided or acquired through systematic research.	Candidates apply their skills, knowledge and understanding in appropriate vocational contexts: • by describing , explaining, interpreting and evaluating information and the impact on society of the work of scientists, including beneficial effects and the need for constraints; • in carrying out relevant calculations.	Candidates: • carry out safely and skilfully practical tasks, making and recording observations and measurements with appropriate precision, processing them appropriately and communicating this information clearly and logically, e.g. in prose, tables and graphs; • plan, carry out and evaluate investigative work.	
AS A/B boundary Performance Descriptions	Candidates: • demonstrate their knowledge and understanding of science with few omissions; • use scientific terminology and conventions accurately in their work; • select relevant information, present it clearly, logically, and then evaluate it.	Candidates: • describe, interpret and explain phenomena and effects using scientific principles; • apply scientific facts and principles to familiar and unfamiliar situations; • describe, interpret and evaluate quantitative and qualitative data; • identify and explain issues arising from scientific activities, which impact on society; • carry out straightforward calculations, obtaining correct solutions to an appropriate degree of accuracy.	In given practical tasks, candidates: • produce risk assessments, consistent with COSHH guidelines, and use them to carry out given tasks safely, using a range of techniques and equipment with an appropriate degree of accuracy; • make and record relevant observations and measurements with appropriate precision and process these accurately; • interpret their results and draw conclusions.	Candidates use written expression which: • conveys appropriate meaning; • uses appropriate specialist vocabulary.
AS E/U boundary Performance Descriptions	Candidates: • demonstrate some knowledge and understanding of science; there may be significant omissions; • use basic scientific terminology and conventions in their work; • select and clearly present information.	Candidates: • describe phenomena and effects using scientific principles; • apply scientific facts and principles to familiar situations; • describe and give limited interpretation of quantitative and qualitative scientific data; • describe issues arising from scientific activities, which impact on society; • carry out straightforward calculations sometimes obtaining correct solutions.	In given practical tasks, candidates, with guidance: • use risk assessments and carry out given tasks safely using a range of techniques and equipment; • make and record relevant observations and measurements; • provide some interpretation of their results.	Candidates use written expression which: • is adequate to convey meaning; • may be expressed in a non-specialist way.

A2 A/B boundary Performance Descriptions	Candidates: • demonstrate their knowledge and understanding of science from most parts of the specification; • use scientific terminology and conventions accurately in all their work; • select relevant information, present it clearly and logically, and then evaluate and justify it.	Candidates: • describe, interpret and explain phenomena and effects using scientific principles; • apply scientific facts and principles to familiar and unfamiliar situations; • describe, interpret and evaluate quantitative and qualitative data; • identify and explain issues arising from scientific activities, which impact on society; • carry out complex calculations, obtaining correct solutions to an appropriate degree of accuracy.	In all practical tasks, candidates: • produce risk assessments, consistent with COSHH guidelines, and use them to carry out their tasks safely, using a range of techniques and equipment with an appropriate degree of accuracy; • make and record relevant observations and measurements with appropriate precision and process these accurately; • interpret their results and draw conclusions, discussing their significance. In the synoptic investigation, candidates also: • independently make a realistic and achievable plan for an investigation, linked to other areas of the AS GCE/Advanced GCE specification; • critically evaluate their investigation, incorporating amendments into the plan where appropriate; • produce a logical and well-structured report of their investigation, showing detailed scientific understanding of their work.	Candidates use written expression which: • conveys appropriate meaning; • uses appropriate specialist vocabulary.
A2 E/U boundary Performance Descriptions	Candidates: • demonstrate some knowledge and understanding of science; there may be significant omissions; • use some scientific terminology and conventions in their work; • select and clearly present information.	Candidates: • describe phenomena and effects using scientific principles; • apply scientific facts and principles to familiar situations; • describe and give limited interpretation of quantitative and qualitative scientific data; • describe issues arising from scientific activities, which impact on society; • carry out straightforward calculations, generally obtaining correct solutions.	In all practical tasks, candidates: • use risk assessments to carry out their tasks safely, using a range of techniques and equipment; • make and record relevant observations and measurements; • provide, with guidance, some interpretation of their results in terms of their scientific knowledge and understanding. In the synoptic investigation, candidates also: • make a plan for an investigation, linked to other areas of the AS GCE/Advanced GCE specification; • make an appropriate evaluation of the investigation; • produce a clear and accurate report of their investigation.	Candidates use written expression which: • is adequate to convey meaning; • may be expressed in a non-specialist way.

Appendix B: Coursework Assessment Evidence Grids

Unit G620 - Assessment Evidence Grid

Unit G620: Science at work

What the candidate needs to do:

The candidate needs to produce a research portfolio related to information on organisations that use science [**50** marks].

This evidence needs to include:

AO1: records of the candidate's survey of **four** science-based organisations; an in-depth study of **one** of them, including information on health and safety issues [**19**];

AO2: information showing an understanding of the impact on society of the candidate's **one** chosen organisation, with evidence that the candidate has completed relevant calculations *either* using provided data *or* on at least **one** practical procedure carried out [**10**];

AO3: evidence that the candidate has completed safely **two** practical procedures and recorded, processed and evaluated the results [**21**].

How the candidate will be assessed:

Assessment Objective	Mark Band 1	Mark Band 2	Mark Band 3	Mark Awarded
AO1	Candidate will demonstrate they have carried out a survey on **four** science-based organisations with some information selected and presented, generally using correct spelling, punctuation and grammar; **[0 1 2]**	candidate will demonstrate a researched survey on **four** science-based organisations with the relevant information selected and clearly presented, generally using correct terminology, spelling, punctuation and grammar; **[3 4]**	candidate will demonstrate a thorough researched survey on **four** science-based organisations with evidence that relevant information has been selected from a range of sources and is clearly and logically presented, using accurate terminology, correct spelling, punctuation and grammar. **[5 6]**	
	Candidate will produce a study on **one** science-based organisation which shows some information has been selected and presented, generally using correct spelling, punctuation and grammar; **[0 1 2]**	candidate will produce a researched study based on **one** science-based organisation with relevant information selected and clearly and logically presented, generally using correct terminology, spelling, punctuation and grammar; **[3 4 5]**	candidate will produce a thorough researched in-depth study on **one** science-based organisation, with evidence that relevant information has been selected from a range of sources and is clearly and logically presented, using accurate terminology and correct spelling, punctuation and grammar; candidate will include some evaluation and justification of the material used. **[6 7]**	
	Candidate will demonstrate a basic knowledge and understanding of health and safety laws and regulations; **[0 1 2]**	candidate will demonstrate knowledge and understanding of the appropriate health and safety laws and regulations; there will be few omissions or inaccuracies; **[3 4]**	candidate will demonstrate a comprehensive knowledge and understanding of health and safety laws and regulations with information on how organisations comply with the legislation. **[5 6]**	**/19**

Unit G620: Science at work (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO2	Candidate will include some understanding of the impact one organisation has on society; this lacks detail and includes some omissions; **[0 1 2]**	candidate will include a detailed and researched study of the impact of one organisation on society; the report will have few errors or omissions; **[3 4]**	candidate will produce a comprehensive and thoroughly researched study of the impact of one organisation on society focusing on all the issues stated. **[5 6]**	
	Candidate will perform a number of straightforward calculations using provided data, or data obtained from one practical procedure, and generally obtain the correct solutions; **[0 1]**	candidate will perform a number of straightforward and complex calculations using provided data, or data obtained from at least one practical procedure, and generally obtain the correct solutions; **[2 3]**	candidate will perform a number of straightforward and complex calculations using researched data, or data obtained from at least one practical procedure, and obtain the correct solutions to an appropriate degree of accuracy. **[4]**	**/10**
AO3	Candidate will record evidence of the completion of two practical tasks linked to a vocational context in which risk assessments have been used; **[0 1 2 3 4]**	candidate will record evidence of the confident completion of two practical tasks linked to a vocational context in which risk assessments have been developed and used; **[5 6]**	candidate will record evidence of the accurate completion of two practical tasks linked to a vocational context in which risk assessments have been produced with evidence that equipment has been used safely and to the appropriate degree of accuracy. **[7 8]**	
	Candidate has made and recorded relevant observations or measurements; **[0 1 2]**	candidate has made and recorded all relevant observations or measurements; **[3 4]**	candidate has made and accurately recorded all relevant observations or measurements with the appropriate precision. **[5 6]**	
	Candidate has suitably processed results, with some interpretation; **[0 1 2]**	candidate has accurately processed and interpreted the results drawing basic conclusions; **[3 4 5]**	candidate has accurately processed and interpreted all results and evaluated where appropriate. **[6 7]**	**/21**
			Total mark awarded:	**/50**

Unit G621 - Assessment Evidence Grid

Unit G621: Analysis at work

What the candidate needs to do:

The candidate needs to produce a portfolio related to information on organisations that use science to analyse processes [**50** marks].

This evidence needs to include:

AO1: relevant research, understanding and detail in a study of **one** organisation to produce a report for that organisation which considers their energy policy and energy usage; the report must include a consideration of their energy efficiency and environmental impact [**19**];

AO2: a study of large-scale and small-scale generation, to include energy transfer involved; to include data and calculations to show a comparison of fuel/energy costs [**10**];

AO3: evidence that the candidate has safely completed **three** practical analyses – to include a range of **both** qualitative and quantitative analysis– each needs to be appropriately recorded, processed and evaluated [**21**].

How the candidate will be assessed:

Assessment Objective	Mark Band 1	Mark Band 2	Mark Band 3	Mark Awarded
AO1	Candidate will give a brief description of the energy policy of a non-domestic consumer of electricity; **[0 1 2]**	candidate will give selected information obtained from a non-domestic consumer of energy to give a description about their energy policy; **[3 4]**	candidate will give selected, relevant information obtained from a non-domestic consumer of energy, to give a detailed description of their energy policy and evaluate ways in which they limit their energy consumption. **[5 6]**	
	Candidate will state what is meant by energy efficiency and state how the candidate's non-domestic consumer of energy has considered energy efficiency by • carrying out processes or activities more efficiently • eliminating wasteful processes or activities • other means; **[0 1 2]**	candidate will state what is meant by energy efficiency and describe how energy efficiency has been considered by the candidate's chosen non-domestic consumer of energy by • carrying out processes or activities more efficiently (include a definition of energy efficiency) • eliminating wasteful processes or activities • other means generally using accurate terminology and nomenclature; **[3 4]**	candidate will state what is meant by energy efficiency and explain how energy efficiency has been considered by the candidate's chosen non-domestic consumer of energy and evaluate the reduction of energy consumption by • carrying out processes or activities more efficiently (relate this to efficiency) • eliminating wasteful processes or activities • other means using accurate terminology and nomenclature. **[5 6]**	

Unit G621: Analysis at work (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO1	Candidate will state how their chosen organisation has considered the • environmental impacts • cost savings of reducing energy consumption, generally using correct, spelling, punctuation and grammar; **[0 1 2]**	candidate will describe how their chosen organisation has considered the • environmental impacts • cost savings of reducing energy consumption, generally using correct terminology, spelling, punctuation and grammar; **[3 4 5]**	candidate will describe in detail how their chosen organisation has considered the • environmental impacts • cost savings of reducing energy consumption and relate it to the energy policy of the organisation, using accurate terminology, correct spelling, punctuation and grammar. **[6 7]**	**/19**
AO2	Candidate will show the forms of energy transfer involved in the generation of electricity; candidate will describe briefly large-scale and small-scale electrical generation from one chosen fuel or energy sources; **[0 1]**	candidate will describe and compare large-scale and small-scale electrical generation from two chosen fuel or energy sources; candidate will demonstrate good research skills and evidence of selection of material; **[2 3]**	candidate will describe and compare the relative benefits and problems of large-scale and small-scale electrical generation from two chosen fuel or energy sources; candidate will demonstrate independent research skills and evidence of selection of relevant material. **[4 5]**	**/10**
	Candidate will display information on energy values and fuel/energy costs to include • one non-renewable • one renewable fuel/energy source used in the generation of electricity; candidate will show a number of straightforward calculations using the candidate's data, generally obtaining the correct solutions; **[0 1]**	candidate will research and display information on energy values and fuel/energy costs to include • one non-renewable • one renewable fuel/energy source used in the generation of electricity; candidate will show a number of complex and straightforward calculations using the data researched, generally obtaining the correct solutions; **[2 3]**	candidate will research and display information on energy values and fuel/energy costs to include a range of • non-renewable • renewable fuel/energy sources used in the generation of electricity; candidate will show a number of complex and straightforward calculations using the data researched, obtaining the correct solutions to an appropriate degree of accuracy. **[4 5]**	

Unit G621: Analysis at work (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO3	Candidate will produce a report of a qualitative analysis they have carried out, linked to a vocational context in which risk assessments have been used; relevant observations have been made and results suitably processed, with some interpretation; **[0 1 2 3]**	candidate will produce a detailed report of a qualitative analysis they have carried out, linked to a vocational context in which risk assessments have been completed; relevant observations have been made and results accurately processed and interpreted; the information is presented clearly and logically; **[4 5]**	candidate will produce a detailed report of a qualitative analysis they have carried out, linked to a vocational context in which risk assessments have been produced with evidence equipment has been used safely and to the appropriate degree of accuracy; relevant observations have been made and results accurately processed and interpreted; the information is presented clearly, logically and has been evaluated. **[6 7]**	
	Candidate will produce a report of a quantitative analysis they have carried out, linked to a vocational context in which risk assessments have been used; relevant observations have been made and results suitably processed, with some interpretation; **[0 1 2 3]**	candidate will produce a detailed report of a quantitative analysis they have carried out, linked to a vocational context in which risk assessments have been completed; relevant observations have been made and results processed and interpreted accurately; the information is presented clearly and logically; **[4 5]**	candidate will produce a detailed report of a quantitative analysis they have carried out, linked to a vocational context in which risk assessments have been produced, with evidence that equipment has been used safely and to the appropriate degree of accuracy; relevant observations have been made and results processed and interpreted accurately; the information is presented clearly and logically and has been evaluated. **[6 7]**	
	Candidate will produce a report of a **third** investigation they have carried out, linked to a vocational context in which risk assessments have been used; relevant observations or measurements have been made and results suitably processed, with some interpretation; **[0 1 2 3]**	candidate will produce a detailed report of a **third** investigation they have carried out, linked to a vocational context in which risk assessments have been completed; relevant observations or measurements have been made and results accurately processed and interpreted; the candidate's information will be presented clearly and logically; **[4 5]**	candidate will produce a detailed report of a **third** investigation they have carried out, linked to a vocational context in which risk assessments have been produced with evidence equipment has been used safely and to the appropriate degree of accuracy; relevant observations or measurements have been made with the appropriate precision and results accurately processed and interpreted; the candidate's information will be presented clearly, logically and has been evaluated. **[6 7]**	**/21**
			Total mark awarded:	**/50**

Unit G624 - Assessment Evidence Grid

Unit G624: Chemicals for a purpose

What the candidate needs to do:

The candidate needs to provide evidence of their knowledge, understanding and investigation into chemicals for a purpose [**50** marks].

This evidence needs to include**:**

AO1: a description of **two** examples of **inorganic** and **two** examples of **organic** chemical compounds, discussing their chemical structure, properties and uses and a detailed account of the chemistry of two compounds (one of which is made from oil) [**21**];

AO2: relevant research of one industrial process that involves the use of a catalyst, whose action the candidate will explain. The candidate's report will include an understanding of the social, economic and environmental impact of the product produced in the process [**10**];

AO3: a sample and account of the preparation of two products that have been synthesized, purified and analyzed in the laboratory [**19**].

How the candidate will be assessed:

Assessment Objective	Mark Band 1	Mark Band 2	Mark Band 3	Mark Awarded
AO1	Candidate will give **four** examples of chemical compounds (two inorganic and two organic) stating for each compound its • name • formula • structures; **[0 1]**	candidate will give **four** examples of chemical compounds (two inorganic and two organic), stating for each compound its • name • appropriate formula (e.g. displayed) • structures with a simple explanation of the bonding involved; the data will be presented systematically and research will show some evidence of selection; **[2 3]**	candidate will give **four** examples of chemical compounds (two inorganic and two organic) stating for each compound its • name • appropriate formula • structures to include a detailed explanation of the bonding involved; the candidate's research will show that relevant information has been selected and suitably referenced. **[4 5]**	
	For each of the **four** chosen compounds, candidate will present clearly the • uses • properties; **[0 1]**	for each of the **four** compounds, candidate will show • how the uses depend upon the properties; information will be clearly presented and research will show some evidence of selection; **[2 3]**	for each of the **four** compounds, candidate will show how the • properties depend upon structure • uses depend upon the properties using appropriate scientific terminology; information will be clearly presented and the candidate's research will show that relevant information has been selected and suitably referenced. **[4 5]**	

Unit G624: Chemicals for a purpose (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO1	Candidate will produce an account of the chemistry of **two** compounds, one of which is made from oil; the account will include • physical properties • chemical properties • preparation • uses; evidence of some scientific terminology used with corrected punctuation and grammar; **[0 1 2 3 4 5]**	candidate will produce a detailed account of the chemistry of **two** compounds, one of which is made from oil; the account will include • physical properties • chemical properties • preparation • uses • relevant reactions; appropriate scientific terminology will be used, mainly correct punctuation and grammar, and show that research information has been selected; **[6 7 8]**	candidate will produce a detailed account of the chemistry of **two** compounds, one of which is made from oil; the account will include • physical properties • chemical properties • preparation • uses • structure of the compounds • explanation of relevant reactions; the appropriate use of scientific terminology with correct spelling, punctuation and grammar and Information selected is clearly presented and suitably referenced. **[9 10 11]**	**/21**
AO2	Candidate will show evidence of completion of simple calculations of actual and theoretical yields; **[0 1]**	candidate will show evidence of completion of calculating % yields and calculating costs of producing chemicals; **[2]**	candidate will show evidence of completing to the appropriate degree of accuracy a number of simple and complex calculations using researched data on costs of chemicals and data obtained from at least one of the preparations. **[3]**	**/10**
	Candidate will give an outline of **one** industrial process in which a catalyst is used; the outline will include • the role of the catalyst • raw materials • products • conditions and the usefulness of the product will be stated; **[0 1 2]**	candidate will give a detailed description of **one** industrial process in which a catalyst is used; the description will include • the role of the catalyst • raw materials • products • conditions • chemical equations; energy costs, waste products, availability and sustainability of raw materials will be considered; **[3 4]**	candidate will give a fully researched, detailed account of **one** industrial process in which a catalyst is used; the account will include • a description and explanation of the role of the catalyst • raw materials • products • conditions • chemical equations; an understanding of the social, economic and environmental impact of the product will be discussed. **[5 6 7]**	

Unit G624: Chemicals for a purpose (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO3	Candidate will research the compound chosen and present evidence of the completion of a workable method with a safe risk assessment for the laboratory preparation of an • inorganic compound [1] • organic compound [1]; **[0 1 2]**	candidate will research the compound and present evidence of the confident completion of a detailed method with a safe risk assessment for the laboratory preparation of an • inorganic compound [2] • organic compound [2]; evidence of the completion of some basic analysis should be included; **[3 4]**	candidate will show suitable selected relevant research and present evidence of the accurate completion of a detailed method with a safe risk assessment for the laboratory preparation of an • inorganic compound [3] • organic compound [3] with evidence of purification and analysis included; the risk assessment must be detailed and accurate. **[5 6]**	
	Candidate will present observations and results for each preparation using tables and diagrams; candidate has suitably processed some results for • inorganic compound [1] • organic compound [2]; **[0 1 2 3]**	candidate will accurately record observations, measurements and results for each preparation; candidate has processed results for • inorganic compound [2] • organic compound [3]; **[4 5]**	candidate will accurately record all observations, measurements and results for each preparation and analysis; candidate will have accurately processed the results for • inorganic compound [3] • organic compound [4]. **[6 7]**	
	Candidate will evaluate the preparations and will indicate how the yield could be increased for • inorganic compound [1] • organic compound [1]; **[0 1 2]**	candidate will evaluate the preparations and analysis; candidate will state workable suggestions about increasing the yield for • inorganic compound [2] • organic compound [2]; **[3 4]**	candidate will evaluate systematically the preparations and analysis and give workable suggestions for increasing the yield for • inorganic compound [3] • organic compound [3]. **[5 6]**	**/19**
			Total mark awarded:	**/50**

Unit G625 - Assessment Evidence Grid

Unit G625: Forensic science

What the candidate needs to do:

The candidate needs to produce evidence of their investigation into forensic science [**50** marks].
This evidence needs to include**:**

AO1: a knowledge and understanding of the need to preserve and record the crime scene and the chemical, biological and physical techniques used to collect and visualise forensic evidence safely, including ethical considerations [**21**];

AO2: a report on a forensic case study on evidence and proof; work which demonstrates the use of calculations to support forensic measurements or observations [**10**];

AO3: at least **one** forensic analysis in **each** of the following areas: biological, chemical and physical techniques [**19**].

How the candidate will be assessed:

Assessment Objective	Mark Band 1	Mark Band 2	Mark Band 3	Mark Awarded
AO1	Candidate will demonstrate a basic knowledge of the need to record and preserve the crime scene, giving some of the techniques used; **[0 1 2]**	candidate will demonstrate knowledge and understanding of the need to record and preserve the crime scene, describing a range of techniques used; **[3 4]**	candidate will demonstrate a thorough knowledge and understanding of the need to record and preserve the crime scene with a detailed description and explanation of a wide range of techniques used. **[5]**	
	The candidate's work will show some information on how forensic scientists collect and visualise evidence safely using • chemical techniques; **[0 1]** • biological techniques; **[0 1]** • physical techniques; **[0 1]** with evidence of some scientific terminology and corrected punctuation and grammar;	the candidate's work will show research and information on ways in which forensic scientists collect and visualise evidence, safely and appropriately, using • chemical techniques; **[2]** • biological techniques; **[2]** • physical techniques; **[2]** generally, candidate will use appropriate scientific terms correctly, and use correct punctuation and grammar;	candidate will produce an in-depth research report showing understanding of a range of ways in which forensic scientists collect and visualise evidence, safely and appropriately, using • chemical techniques; **[3 4]** • biological techniques; **[3 4]** • physical techniques; **[3 4]** candidate will understand the science behind these techniques and use appropriate scientific terms and conventions correctly, with correct spelling, punctuation and grammar.	
	The candidate's work will show a basic knowledge of ethical issues involved in retaining samples or data; **[0 1]**	the candidate's work will show a range of information on ethical issues related to forensic science; **[2 3]**	the candidate's work will show a range of relevant information on ethical issues in forensic science and an understanding of the need for an ethical code. **[4]**	**/21**

Unit G625: Forensic science (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO2	The candidate's report, based on a case study, will contain some information on evidence and proof including information on the strengths and limitations of some types of forensic evidence; **[0 1 2]**	the candidate's report, based on a case study, will contain detailed information on evidence and proof which includes • the ways in which forensic scientists ensure that the quality of evidence collected and analysed is objective; • strengths and limitations of the analytical techniques used and some interpretation of the probability of guilt; **[3 4]**	the candidate's report, based on a case study, will contain researched and relevant detailed information on evidence and proof which includes • the ways in which forensic scientists ensure that the quality of evidence collected and analysed is objective; • detail on limitations; • strengths and weaknesses of the analytical techniques used; • an understanding of the probability of guilt and of a need to review evidence. **[5 6]**	
	Candidate will complete straightforward calculations on forensic data and will sometimes obtain the correct solutions; **[0 1]**	candidate will complete straightforward calculations on forensic data and will obtain the correct solutions; **[2 3]**	candidate will complete more complex calculations and will obtain the correct solutions to an appropriate degree of accuracy. **[4]**	**/10**
AO3	Candidate will safely carry out **one** forensic analysis in **each** of the **three** areas • biological • chemical • physical and record evidence of completion; candidate will use risk assessments; **[0 1 2 3 4]**	candidate will carry out at least **one** forensic analysis in **each** of the **three** areas • biological • chemical • physical safely and with some skill and confidence; candidate will produce and use suitable risk assessments and record evidence of completion; candidate will use a range of techniques and equipment and repeat some measurements where necessary; candidate will work with an appropriate degree of accuracy; **[5 6]**	candidate will carry out at least **one** forensic analysis, in **each** of the **three** areas • biological • chemical • physical safely, skilfully, and accurately using different techniques; candidate will produce detailed risk assessments and use them appropriately and record evidence of completion; candidate will explain why they used the range of techniques and equipment and repeat measurements where appropriate; candidate will work with an appropriate degree of accuracy throughout. **[7 8]**	
	Candidate will make and record at least **one** set of forensic observations or measurements in each area and display the data obtained; **[0 1 2]**	candidate will make and record at least **one** set of appropriate forensic observations or measurements in each area, using some precision in their measurements, and display the data accurately in a range of ways; **[3]**	candidate will make and record at least **one** set of relevant forensic observations and measurements in each area, using the appropriate precision in the candidate's measurements, and candidate will display the data accurately in a range of ways. **[4 5]**	
	Candidate will attempt to process and interpret some results in each of the **three** areas; **[0 1 2]**	candidate will process and interpret their results in each of the **three** areas; **[3 4]**	candidate will process and interpret their results in each of the **three** areas in detail, discussing their significance. **[5 6]**	**/19**
			Total mark awarded:	**/50**

Unit G626 - Assessment Evidence Grid

Unit G626: The physics of sport

What the candidate needs to do:

The candidate needs to produce evidence of their investigation into the physics of sport [**50** marks].

This evidence needs to include**:**

AO1: a series of four short guidance leaflets for the coaches at a sport and recreation centre to help them answer questions of a technical nature from their trainees:

- a *'Measurement in Sport'* leaflet which will include the units, devices and techniques used for making measurements of **four** different quantities in specified sports of the candidate's choice;
- a '*Seeing in Sport'* leaflet which will include the structure of the eye and how it forms an image, related to **one** chosen sport where good vision is of critical importance;
- a '*Movement in Sport'* leaflet which will include an account of how chemical energy is most efficiently converted into useful mechanical work using the muscles, bones and joints of **one** or more limbs and related to **one** chosen sport where efficient movement is of critical importance;
- a '*Technique in Sport'* leaflet which will include **one** example related to a specified sport of their choice of either collisions, trajectories of moving objects or lift, e.g. in aerofoils [**21**];

AO2: a presentation which will discuss the required material properties and how these are achieved in sports equipment; evidence that the candidate has completed a number of calculations related to the physics of sport [**10**];

AO3: evidence that the candidate has obtained information by experimental investigation relating to the physics of sport [**19**].

How the candidate will be assessed:

Assessment Objective	Mark Band 1	Mark Band 2	Mark Band 3	Mark Awarded
AO1	Candidate will demonstrate some knowledge and understanding of the facts, phenomena and principles involved in the unit in their • *'Measurement in Sport'* leaflet; **[0 1 2]** • *'Seeing in Sport'* leaflet; **[0 1 2]** • *'Movement in Sport'* leaflet; **[0 1 2]** • *'Technique in Sport'* leaflet; **[0 1 2]**	candidate will demonstrate an extensive knowledge and understanding of the facts, phenomena and principles in their leaflets; there may be minor omissions but there are no serious scientific errors in their • *'Measurement in Sport'* leaflet; **[3]** • *'Seeing in Sport'* leaflet; **[3]** • *'Movement in Sport'* leaflet; **[3]** • *'Technique in Sport'* leaflet; **[3 4]**	candidate will demonstrate comprehensive and detailed knowledge and understanding of the facts, phenomena and principles in their • *'Measurement in Sport'* leaflet; **[4 5]** • *'Seeing in Sport'* leaflet; **[4 5]** • *'Movement in Sport'* leaflet; **[4 5]** • *'Technique in Sport'* leaflet; **[5 6]**	**/21**

Unit G626: The physics of sport (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO2	Candidate will produce an Equipment in Sport presentation which shows some relevant physical principles relating to the choice of material for specific sports equipment showing corrected spelling, punctuation and grammar; **[0 1 2]**	candidate will produce an Equipment in Sport presentation which shows that they can identify the relevant physics principles relating to the choice of material for specific sports equipment; although there may be minor errors and omissions, their explanations will be clear and accurate, mainly with correct spelling, punctuation and grammar; **[3 4]**	candidate will produce an Equipment in Sport presentation which shows that they can accurately identify the underlying physics principles relating to the choice of material for specific sports; candidate will correctly use the principles to give a clear, accurate and logical explanation, spelling, punctuation and grammar is correct. **[5 6]**	
	Candidate will show that they can perform a number of simple calculations using provided data, relating to the physics of sport; **[0 1]**	candidate will show that they can perform a number of simple and complex calculations using researched data relating to the physics of sport, and their use of mathematics is generally accurate and correct; **[2 3]**	candidate will show that they can perform a number of simple and complex calculations using researched data, relating to the physics of sport, and use mathematical techniques confidently, accurately and appropriately and where relevant to enhance the explanations in experimental investigations. **[4]**	**/10**
AO3	Candidate will show that they can plan two investigations and provide evidence that they can conduct them safely using risk assessments; candidate will show that they have used a range of equipment; **[0 1 2]**	candidate will show that they can plan two investigations and provide evidence that they can conduct them confidently and safely; candidate will produce and follow risk assessments; candidate will show that they have used a range of equipment and techniques; **[3 4]**	candidate will show that they can plan and conduct two investigations safely in accordance with their risk assessments which are comprehensive, and use equipment to the appropriate degree of accuracy; candidate will show that they have used a wide range of equipment and techniques. **[5 6]**	
	Candidate has obtained and recorded some valid data; **[0 1 2]**	candidate has obtained adequate valid data and repeat measurements; candidate has recorded data in a suitable form and usually to an appropriate degree of precision; **[3 4]**	candidate has obtained ample valid data and repeat measurements; candidate has recorded data clearly and to an appropriate level of precision. **[5 6]**	
	Candidate has suitably processed and interpreted results and drawn basic conclusions; **[0 1 2]**	candidate has accurately processed and interpreted results drawing conclusions relating to the investigations; **[3 4 5]**	candidate has accurately processed and interpreted all results in detail and drawn logical conclusions, discussing their significance to the investigations, evaluating where appropriate. **[6 7]**	**/19**
			Total mark awarded:	**/50**

Unit G627 - Assessment Evidence Grid

Unit G627: Investigating the scientist's work

What the candidate needs to do:

The candidate needs to produce an information pack, which can be used and understood by a group of scientific research technicians [**50** marks].

This evidence needs to include**:**

AO1: a detailed and workable plan for **one** scientific vocational investigation, to include aims and objectives, full details of experimental work, and constraints under which the candidate will need to work, with documented evidence of research [**10**];

AO2: evidence showing the tracking and understanding of the outcomes of the investigation with evidence that data collected has been processed and interpreted [**14**];

AO3: evidence to show the investigation was implemented safely and produce an evaluative scientific report on the outcomes of the investigation suitable for the technicians to understand and use [**26**].

How the candidate will be assessed:

Assessment Objective	Mark Band 1	Mark Band 2	Mark Band 3	Mark Awarded
AO1	Candidate will produce a workable and clearly presented plan for **one** investigation linked to a vocational context; the plan shows • the aims and objectives • a basic knowledge of the scientific principles • experimental techniques to be used • timing for activities • information on deadlines candidate will need to be aware of; **[0 1 2]**	candidate will produce an achievable and logically presented plan, for **one** investigation with direct vocational involvement which shows • a sound knowledge and understanding of the aims and objectives set • a range of experimental techniques which will be used • appropriate detailed time information for all activities • identification of constraints candidate will have to work under and how they can be overcome; **[3]**	candidate will produce a comprehensive, realistic, achievable and logically presented plan for **one** suitable investigation which demonstrates • a thorough knowledge and understanding of the objectives • a wide range of experimental techniques which will be used • appropriate workable time guidelines • identification and discussion of the constraints, their effect and suitable contingency plans. **[4 5]**	
	Candidate will show evidence of selected research about an investigation to include • vocational links • suitable experimental work • health and safety guidance • referencing of sources used; **[0 1 2]**	candidate will show evidence of a wide range of relevant research, selected from a number of sources about an investigation to include • relevant vocational links • a range of experimental work • related health & safety guidance • related referencing of sources; **[3]**	candidate will show evidence of thorough research and suitable selection of information from a wide range of sources, about an investigation to include • researched vocational links • a wide range of experimental work • detailed & relevant health & safety guidance • suitable referencing and validation of sources used. **[4 5]**	**/10**

G627: Investigating the scientist's work (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO2	Candidate will produce a record of monitoring their plan with reasons showing how the plan has been followed; **[0 1 2]**	candidate will show evidence of monitoring their plan, how the plan has been followed and include any modifications or changes needed to be made, providing reasons for the changes; **[3]**	candidate show detailed evidence of monitoring their plan and will carry out and provide explanations of any strategies used to overcome any deficiencies or constraints of the plan. **[4]**	**/14**
	Candidate will interpret the outcomes of the investigation and discuss its success; **[0 1]**	candidate will assess the reliability of the outcomes and the data and discuss how well the investigation achieved its aims; **[2 3]**	candidate will discuss the reliability of the investigation with a detailed scientific discussion of how the investigation achieved its aims and objectives. **[4 5]**	
	Candidate will carry out a number of completed straightforward calculations which are linked to the investigation; **[0 1 2]**	candidate will carry out a number of straightforward and complex calculations completed with partial success and accuracy which are linked to the investigation; **[3]**	candidate will accurately and correctly complete a number of complex calculations which are linked to the investigation, giving answers to the correct number of significant figures. **[4 5]**	

G627: Investigating the scientist's work (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO3	Candidate will provide evidence that the experimental procedures or trials in the investigation have been carried out safely and correctly and repeated where necessary using risk assessments; **[0 1 2]**	candidate will show evidence that a range of experimental techniques and procedures has been safely and skilfully completed using suitably detailed risk assessments and within the constraints of the plan; candidate will demonstrate that an appropriate degree of accuracy has been used; **[3 4]**	candidate will show evidence that a wide range of experimental techniques and procedures has been safely, skilfully, accurately and independently completed, using detailed risk assessments which they have produced. **[5 6]**	
	Candidate will produce a clear and accurate report of the outcomes of the investigation, using basic scientific terminology correctly, which can be understood by research technicians with evidence of corrected spelling, punctuation and grammar; **[0 1 2]**	candidate will produce a logical and accurate report of the outcomes of the investigation, using scientific terminology correctly, with correct punctuation and grammar, which can be understood and used by research technicians; there is evidence to show understanding of the scientific concepts involved in the investigation; **[3 4 5]**	candidate will produce a logical and well-structured report of the outcomes of the investigation using all the appropriate scientific terminology, with correct spelling, punctuation and grammar suitable for use by scientific technicians; this will show a high level of scientific knowledge and understanding relevant to the investigation and its applied implications. **[6 7]**	
	Candidate will record the results of the investigation and present them in a suitable format; **[0 1]**	candidate will accurately record results and outcomes of the investigation and present them in a suitable format including a suitable description and explanation; **[2 3]**	candidate will accurately record to the appropriate precision and present results of the investigation in a suitable manner and provide a detailed explanation. **[4]**	
	Candidate will show processing and interpretation of the data collected with a suitable link to the vocational context set; **[0 1 2]**	candidate will show suitable accurate processing and interpretation of the data collected, relating to the objectives of the investigation; **[3]**	candidate will show evidence that the appropriate method of processing has been selected and accurately and correctly used with any anomalous data identified and evaluated; candidate provides a critical analysis of the results relating to the objectives of the investigation. **[4 5]**	
	Candidate will produce a basic evaluation of the investigation; **[0 1]**	candidate will produce an evaluation of the investigation; **[2 3]**	candidate will produce a critical evaluation of the investigation, incorporating suitable amendments where appropriate. **[4]**	**/26**
			Total mark awarded:	**/50**

Unit G629 - Assessment Evidence Grid

Unit G629: Synthesizing organic chemicals

What the candidate needs to do:

The candidate needs to produce evidence of their investigation into synthesizing organic chemicals [**50** marks].

This evidence needs to include**:**

AO1: a report or leaflet which demonstrates an understanding of organic chemistry by the correct identification and naming of functional groups, the importance of different types of isomerism and different types of reactions involving organic molecules; a report recording an investigation of therapeutic drugs, their usage and mode of action in the body [**6 4**];

AO2: research on a process used to manufacture an organic compound; the candidate needs to show an understanding of the factors to be considered by a manufacturer when scaling up a small-scale process in terms of health and safety, plant design, costs and the use of automation; evidence of appropriate calculations [**14**];

AO3: production of **two** preparations of organic compounds the candidate has made and purified in the laboratory, **one** of which will be a useful drug, and a report for each sample detailing their preparation, method of purification, percentage yield and evaluation [**26**].

How the candidate will be assessed:

Assessment Objective	Mark Band 1	Mark Band 2	Mark Band 3	Mark Awarded
AO1	Candidate will show a basic knowledge and understanding of the classifications of organic compounds and will be able to • name organic compounds • identify functional groups • draw structural and displayed formulae • explain isomerism; their research will show some evidence of selection and suitable referencing; **[0 1]**	candidate will show knowledge and understanding of the classifications of a range of organic compounds and be able to • name organic compounds • identify functional groups • draw structural and displayed formulae • explain isomerism and discuss the difference in properties between isomers; their research will show evidence of the use of selection from a range of sources and suitable referencing; **[2]**	candidate will show a thorough knowledge and understanding of the classifications of a wide range of organic compounds and will be able to • name organic compounds • identify functional groups within molecules • draw structural and displayed formulae • explain the importance of isomerism with relation to the difference in properties between isomers; candidate will show relevant selective information that will be clearly presented and referenced. **[3]**	
	Candidate will show understanding of **four** reaction types by • giving examples using appropriate nomenclature • relating the reaction type to the specific functional group; **[0 1]**	candidate will show understanding of **four** of the reaction types listed in the specifications by • selecting examples using appropriate nomenclature • relating the reaction type to the specific functional group; candidate will describe the reaction types using correct scientific terminology; information will be clearly presented; **[2]**	candidate will show understanding and explain of at **least five** reaction types listed in the specifications by • giving examples using appropriate nomenclature • relating the reaction type to the specific functional group candidate will explain the reaction types using correct scientific terminology; information will be clearly presented. **[3]**	

Unit G629: Synthesizing organic chemicals (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO1	Candidate will research **two** drug types listed in the specifications and show a basic knowledge and understanding of therapeutic drugs, their usage and mode of action in the body; scientific terms and conventions will have generally been used correctly in the report with corrected punctuation and grammar; **[0 1]**	candidate will research **three** of the drug types listed in the specifications and show detailed knowledge and understanding of therapeutic drugs, their usage and mode of action in the body; scientific terms and conventions will have been used correctly in the report with correct punctuation and grammar; **[2 3]**	candidate will research **at least three** drug types listed in the specifications and show a detailed knowledge and understanding of therapeutic drugs, their usage and mode of action in the body; explanations of the therapeutic effect of drugs will be given and the use of the drugs evaluated; scientific terms and conventions will have been used correctly in explanations throughout, with correct spelling, punctuation and grammar. **[4]**	**/10**
AO2	Candidate will produce information on a process used to manufacture an organic compound; candidate will identify most of the factors needed to be considered to ensure a safe and economic process, selecting some appropriate sources and presenting information clearly; **[0 1 2]**	candidate will show researched evidence of a process used to manufacture an organic compound; candidate will identify all the factors needed to be considered to ensure a safe and economic process, selecting a range of appropriate sources and interpreting information clearly; **[3]**	candidate will show detailed and selective research on a process used to manufacture an organic compound; candidate will describe the factors needed to be considered to ensure a safe and economic process, using a wide range of appropriate sources and interpreting information clearly, evaluating and justifying this information, and presenting it clearly, concisely and coherently. **[4 5]**	
	Candidate will find and use information about some of the costs and benefits of the organic compound and its manufacture to • individuals • companies • society; **[0 1 2]**	candidate will find and explain information about the costs and benefits of the organic compound and its manufacture to • individuals • companies • society; information will be clearly presented; **[3]**	candidate will find, explain and evaluate information about the costs and benefits of the organic compound and its manufacture to • individuals • companies • society; information will be presented clearly and concisely. **[4 5]**	
	Candidate will demonstrate that they have completed straightforward calculations either related to their research or to their preparations; some assistance may have been used; **[0 1]**	candidate will demonstrate that they have completed simple and complex calculations correctly either related to their research or to their preparations with little assistance; **[2 3]**	candidate will demonstrate that they have completed correctly and independently complex calculations either related to their research or to their preparations. **[4]**	**/14**

Unit G629: Synthesising organic chemicals (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO3	Candidate will record evidence of the safe completion of the preparation and purification of **two** organic compounds, one of which is a useful drug; you will give evidence of the use of valid risk assessments; **[0 1 2 3 4]**	candidate will record evidence of the planning and the safe completion of the preparation and purification of **two** organic compounds, one of which is a useful drug, using a range of techniques; candidate will give evidence that they have used COSHH data to produce valid risk assessments with some assistance; **[5 6 7 8]**	candidate will record evidence of independent planning and the skilful and safe completion of the preparation and purification of **two** organic compounds, one of which is a useful drug, using a wide range of techniques and justifying reasons for the use of such techniques; candidate will independently produce and use risk assessments using COSHH data where appropriate. **[9 10]**	
	Candidate will make and record some observations and measurements for both preparations and purifications and display information clearly; **[0 1]**	candidate will make and record in a suitable format observations and measurements from both preparations and purifications to the appropriate level of precision; **[2]**	candidate will make and record accurately all relevant observations and measurements from both preparations, with the appropriate precision, and display all information clearly and logically. **[3 4]**	
	Candidate will provide evidence of some processing and interpretation of the results; **[0 1 2]**	candidate will provide evidence of the processing of results from both preparations; the processing will be set out clearly; **[3 4]**	candidate will provide correct processing of all the results from both preparations; the processing will be set out clearly and logically. **[5 6]**	
	Candidate will draw some conclusions related to both preparations and give a basic evaluation of the practical work; **[0 1 2]**	candidate will draw conclusions with explanations related to the outcomes of both preparations and evaluate the practical work suggesting alternative techniques; **[3 4]**	candidate will draw detailed conclusions explaining and evaluating both practicals and suggesting alternative techniques or routes where appropriate. **[5 6]**	**/26**
			Total mark awarded:	**/50**

Unit G630 - Assessment Evidence Grid

Unit G630: Materials for a purpose

What the candidate needs to do:

The candidate needs to produce evidence of selection of materials for **one** specified purpose and of underlying knowledge of types and properties of materials [**50** marks].

This evidence needs to include:

AO1: a presentation or poster and accompanying notes outlining the structures of polymers, metals, ceramics or glasses, and composite materials [**10**];

AO2: one case study describing, in detail, their selection of different preferred materials for a stated purpose. Candidate should use published data on material properties in their selection; calculations of tensile stress and strain, the Young modulus and toughness from a graph of force against extension and details of sample dimensions [**14**];

AO3: reports on
(i) their design and testing of a materials testing device (e.g. an impact (toughness), or hardness - testing machine);
(ii) tests to show the effect of their work-hardening, annealing and tempering treatments;
(iii) the results of their experiments to measure electrical and thermal conductivities or specific heat capacity [**26**].

How the candidate will be assessed:

Assessment Objective	Mark Band 1	Mark Band 2	Mark Band 3	Mark Awarded
AO1	Candidate will produce an outline of the structures of at least **one** example of each of polymers and metals; **[0 1]**	candidate will produce a description, with diagrams, of the structures of at least **two** examples of each of polymers and metals, stating physical properties; **[2 3]**	candidate will produce a description, with diagrams, of the structures of more than **two** examples of each of polymers and metals, relating their structures to physical properties. **[4 5]**	/**10**
	Candidate will produce an outline of the structures of at least **one** example of each of ceramics or glasses and composite materials; **[0 1]**	candidate will produce a description, with diagrams, of the structures of **at least two** examples of each of ceramics or glasses and composite materials, stating physical properties; **[2 3]**	candidate will produce a description, with diagrams, of the structures of **more than two** examples of each of ceramics or glasses and composite materials, relating their structures to physical properties. **[4 5]**	

Unit G630: Materials for a purpose (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO2	Candidate will produce **one** case study in which they are asked to select materials for a stated purpose; candidate will show evidence of researched data on the properties of materials showing • a shortlist of possible materials that meet the requirements, giving reasons for their selection • the material that best meets their objectives using data about the properties • from published data, one alternative material giving reasons for alternatives; **[0 1 2]**	candidate will produce **one** case study in which they are asked to select materials for a stated purpose; candidate will show • evidence of relevant researched data on the properties of materials • a shortlist of possible materials that meet the objectives and constraints with reasons for their selection • the material that best meets their objectives using data to justify their final choice • from published data, at least one alternative material, giving reasons for alternatives; **[3 4 5 6]**	candidate will produce **one** case study in which they are asked to select materials for a stated purpose; candidate will show • evidence of selected relevant researched data on the properties of materials • a shortlist of possible materials that meet their objectives and constraints, fully justifying their selection • the material that best meets their objectives using data about the properties, fully justifying their final choice • from published data, at least two alternative material giving reasons for alternatives. **[7 8 9 10]**	
	Candidate will complete calculations, with some assistance, of tensile stress and strain, the Young modulus and toughness from a given graph of force against extension and length and cross-sectional area of sample; **[0 1 2]**	candidate will complete calculations from given equations of tensile stress and strain, the Young modulus and toughness from a given graph of force against extension and length and cross-sectional diameter of sample; **[3]**	candidate will complete calculations, unaided, of tensile stress and strain, the Young modulus and toughness from a given graph of force against extension and length and cross-sectional diameter of sample, giving answers to the correct number of significant figures. **[4]**	**/14**

Unit G630: Materials for a purpose (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO3	Candidate will produce evidence of the safe use of the testing device and a report on their design and testing of the device, including • a plan and safety precautions • a description and diagram of their device • results suitably recorded • suitable processing of results with interpretation • a basic evaluation; candidate will use basic scientific terminology correctly, with evidence of correct punctuation and grammar; **[0 1 2 3 4]**	candidate will produce evidence of the confident and safe use of the testing device and a report on their design and testing of the device including • an unaided plan and safety precautions • a description and diagram of their device • relevant results accurately recorded • some accurate processing with interpretation and conclusion • a logical evaluation; report will be clear and logical and will use basic scientific terminology correctly, with spelling, punctuation and grammar mainly used correctly; **[5 6 7]**	candidate will produce evidence of independent safe work on their testing device and a report on their design and testing of the device, including • unaided plan and safety precautions • a description and diagram of their method, to include improvements from initial prototype • all results accurately recorded and made to the appropriate precision • accurate processing and interpretation of results with suitable conclusions • detailed evaluation; report is logical and well-structured and uses correct scientific terminology with correct use of spelling, punctuation and grammar throughout. **[8 9 10]**	
	Candidate will produce a report and evidence of simple tests that they have carried out safely on samples and control samples that have been • work-hardened • annealed • tempered; **[0 1 2]**	candidate will produce a report and evidence on simple tests that they have carried out confidently and safely on samples and control samples that have been • work-hardened • annealed • tempered including a comparison of the treated and untreated samples; **[3 4]**	candidate will produce a detailed report and evidence on simple tests that they have carried out independently and safely on samples and control samples that have been • work-hardened • annealed • tempered including an evaluation of whether the treatments have produced the expected result. **[5 6]**	
	Candidate will produce evidence of safe completion of the experiment and a report including safety precautions, from **one** experiment to measure **either** • the electrical conductivity of a sample of resistance wire **or** • the specific heat capacity of a metal sample and specific heat capacity; to include results and calculations of the value of electrical conductivity or specific heat capacity; **[0 1 2 3 4]**	candidate will produce evidence of safe and confident completion of the experiment and a report including safety precautions from each of **one** experiment to measure **either** • the electrical conductivity of a sample of resistance wire **or** • the specific heat capacity of a metal sample and specific heat capacity; to include a full set of results and repeat readings and calculations of the value of electrical conductivity or specific heat capacity and estimate the uncertainty in their result; **[5 6 7]**	candidate will produce evidence of independent and safe completion of the experiment and a report including safety precautions from each of **one** experiments to measure **either** • the electrical conductivity of a sample of resistance wire **or** • the specific heat capacity of a metal sample and specific heat capacity; to include a full set of results and repeat readings and calculations of the value of electrical conductivity or specific heat capacity, estimations of the uncertainty in their result and evaluation of their results compared to data values. **[8 9 10]**	**/26**
			Total mark awarded:	**/50**

Unit G631 - Assessment Evidence Grid

Unit G631: Electrons in action

What the candidate needs to do:

The candidate needs to produce evidence of their investigation into the principles and applications of electrochemical changes [**50** marks].

This evidence needs to include**:**

AO1: a report outlining the applications of stated electrochemical changes [**10**];

AO2: a comparison of commercial cells: non-rechargeable, rechargeable and fuel, including construction, resources, uses, sustainability, efficiency, safety and environmental issues [**14**];

AO3: practical investigations into:
(a) the factors which can change the emf of a cell and those which have no effect;
(b) the factors which affect the efficiency of a simple laboratory experiment in which an object is copper plated [**26**].

How the candidate will be assessed:

Assessment Objective	Mark Band 1	Mark Band 2	Mark Band 3	Mark Awarded
AO1	Candidate will demonstrate a basic knowledge and understanding of the principles of electrochemical change as outlined in the specifications; candidate will give at least **two** examples of the applications of electrochemical change; candidate will use corrected scientific terminology and conventions; **[0 1]**	candidate will demonstrate a sound knowledge and understanding of the principles of electrochemical change as outlined in the specifications; candidate will give a range of examples of the applications of electrochemical change; candidate will give clear explanations and use correct scientific terminology and conventions; **[2 3]**	candidate will demonstrate a thorough knowledge and understanding of the principles of electrochemical change as outlined in the specifications; candidate will give a wide range of examples of the applications of electrochemical change; candidate will give clear explanations and use correct scientific terminology and conventions appropriately. **[4 5]**	
	Candidate will research the application of electrochemical changes in the production of • an electric current • metals; information will have been selected and presented clearly with evidence of corrected punctuation and grammar; **[0 1]**	candidate will research the application of electrochemical changes in the production of • an electric current • metals giving a range of examples; information will have been selected, explained and presented clearly with spelling, punctuation and grammar mainly used correctly; **[2 3]**	candidate will research the application of electrochemical changes in the production of • an electric current • metals giving a wide range of examples; information will have been selected, explained and presented clearly with correct use of spelling, punctuation and grammar throughout. **[4 5]**	**/10**

Unit G631: Electrons in action (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO2	Candidate will research **two** types of commercial cells, giving at least **one** example for each type; candidate will compare the cells for • construction and method of producing an electric current • resources used in production • efficiency • safety and environmental effect • sustainability • use; information will be presented clearly; **[0 1 2 3 4]**	candidate will research **three** types of commercial cells and give at least **one** example for each type; candidate will compare the cells for • construction and method of producing an electric current • resources used in production • efficiency • safety and environmental effect • sustainability • use; information will be explained and presented clearly; **[5 6]**	candidate will research commercial cells and give at least **one** example for a wide range of cells; candidate will compare the cells for • construction and method of producing an electric current • resources used in production • efficiency • safety and environmental effect • sustainability • use; information will be explained in detail and presented clearly. **[7 8]**	**/14**
	Candidate will carry out some straightforward calculations of • emf of cells • quantity of charge; candidate will research and use data to compare the efficiency of commercial cells; **[0 1 2]**	candidate will carry out calculations of • emf of cells • quantity of charge • mass of products; candidate will research and use data to compare the efficiency of commercial cells; candidate will obtain correct solutions; **[3 4]**	candidate will carry out complex calculations of • emf of cells • quantity of charge • mass of products; candidate will research and use data to compare the efficiency of commercial cells; candidate will obtain correct solutions to the appropriate degree of accuracy. **[5 6]**	

Unit G631: Electrons in action (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO3	Candidate will plan suitable experiments to investigate the effect of changing one condition on • emf of a cell • mass of copper deposited during electrolysis; there will be evidence of the use of a risk assessment; **[0 1 2 3 4]**	candidate will plan suitable experiments to investigate the effect of changing conditions on • emf of a cell • mass of copper deposited during electrolysis; candidate will produce risk assessments consistent with COSHH guidelines; candidate will work with an appropriate degree of accuracy; **[5 6]**	candidate will plan suitable experiments to investigate the effect of changing a wide range of conditions on • emf of a cell • mass of copper deposited during electrolysis; one of the changes in conditions should show no effect; candidate will produce detailed risk assessments consistent with COSHH guidelines; candidate will work with an appropriate degree of accuracy and candidate will explain any practical techniques that will improve results. **[7 8]**	
	Candidate will make and record relevant observations and measurements for both experiments; the data will be displayed clearly; **[0 1 2 3 4]**	candidate will make and record relevant observations and measurements for both experiments; the measurements will be recorded to the appropriate degree of accuracy and the data will be displayed clearly; **[5 6]**	candidate will make and record relevant observations and measurements for both experiments; the measurements will be recorded to the appropriate degree of accuracy and the data will be displayed clearly and used in appropriate calculations. **[7 8 9]**	
	Candidate will try to interpret the results for both experiments; **[0 1 2]**	candidate will interpret the results and draw basic conclusions for both experiments and you will evaluate the procedures; **[3 4 5 6]**	candidate will interpret the results in detail and draw conclusions for both experiments; candidate will evaluate the procedures and suggest alternatives. **[7 8 9]**	**/26**
			Total mark awarded:	**/50**

Unit G632 - Assessment Evidence Grid

Unit G632: The mind and the brain

What the candidate needs to do:

The candidate needs to produce evidence of a comprehensive exploration of research methods employed in the study of mind and brain [**50** marks].
This evidence needs to include**:**

AO1: the production of **two** sets of fact sheets designed to raise mental-health awareness, one set on stress and illness, and the second set on research methods employed in the study of the healthy and the damaged brain [**10**];

AO2: an evaluation of the scientific methods and techniques used in the study of mind and brain, together with a consideration of associated ethical issues and evidence of statistical research [**14**];

AO3: the design and safe execution of a simple experiment to investigate **one** aspect of cognitive function and an investigative study on memory [**26**].

How the candidate will be assessed:

Assessment Objective	Mark Band 1	Mark Band 2	Mark Band 3	Mark Awarded
AO1	Candidate will produce **one** fact sheet including selected information about stress and related illness that has been clearly presented; **[0 1 2]**	candidate will produce **one** detailed set of researched fact sheets including a clear definition of stress, its possible causes and its effects on health, with relevant information selected and clearly and logically presented; **[3]**	candidate will produce **one** set of detailed fact sheets, detailed work based on thorough research, including a clear definition of stress, its possible causes and its effects on health with reference to intervention programmes; candidate will provide evidence that relevant information has been selected from a variety of sources and is clearly and logically presented. **[4 5]**	
	Candidate will produce **one** fact sheet including selected information about the study of the brain that has been clearly presented; **[0 1 2]**	candidate will produce **one** detailed set of researched fact sheets that have been clearly presented, based on the study of the brain; **[3]**	candidate will produce **one** set of detailed fact sheets, detailed work based on thorough research, into both the healthy and the damaged brain, with evidence that relevant information has been selected from a variety of sources and is clearly and logically presented. **[4 5]**	**/10**

Unit G632: The mind and the brain (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO2	Candidate will demonstrate a basic knowledge of the methods used in studying the brain and how they are used in an experimental or a clinical setting; **[0 1 2]**	candidate will demonstrate knowledge and understanding of the methods used in studying the brain and explain how they are used in both an experimental and a clinical setting; candidate will mostly use scientific terms accurately; **[3 4 5]**	candidate will demonstrate a thorough knowledge and understanding of the methods used in studying the brain; candidate will explain how such methods are used in both an experimental and a clinical setting, and how they are used in confirming hypotheses regarding normal brain function and in the diagnosis of brain diseases; candidate will use appropriate scientific terms accurately throughout. **[6]**	
	Candidate will carefully select information and present it clearly; candidate will acknowledge the ethical aspects of brain research; **[0 1 2]**	candidate will select carefully a wide range of information, giving reasons for their choice of resources; candidate will present information clearly and logically; candidate will discuss the moral and ethical implications of brain research; **[3]**	candidate will demonstrate an ability to identify the preferable methods for investigating a particular research question; candidate will evaluate information both for and against a method, presenting it clearly and logically; candidate will discuss comprehensively moral, ethical and conceptual considerations associated with the various methods employed in brain research; candidate will provide evidence of statistical research. **[4 5]**	
	Candidate will show evidence of completing simple calculations either using researched statistical evidence or that obtained from their investigative work and prepare a fact sheet showing the results; **[0 1]**	candidate will show evidence of completing simple and complex calculations either using researched statistical evidence or that obtained from their investigative work and prepare a fact sheet showing statistical-test calculations with some summary of results; **[2]**	candidate will show evidence of completing calculations either using researched statistical evidence or that obtained from their investigative work and present a fact sheet with full explanation of the rationale behind the test and result gained. **[3]**	**/14**

Unit G632: The mind and the brain (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO3	Candidate will carry out a simple experiment to evaluate a particular cognitive function following ethical guidelines; **[0 1 2]**	candidate will design and carry out a simple experiment to evaluate a particular cognitive function showing evidence of consideration of ethical guidelines; **[3]**	candidate will design and carry out an experiment to evaluate a particular cognitive function showing evidence of all relevant ethical guidelines and steps taken to reduce risk. **[4 5]**	
	Candidate will plan and investigate a research problem and show that he/she has considered appropriate ethical issues; you will include evidence of basic research using correct punctuation and grammar and show referencing of sources used; **[0 1 2]**	candidate will plan confidently and complete their research problem, identifying its advantages and limitations; candidate will provide evidence that they have considered ethical issues; candidate will include evidence of selected research generally using correct punctuation and grammar and show detailed referencing of sources used; **[3 4 5]**	candidate will plan thoroughly and complete their research problem; candidate demonstrates a clear understanding and justification of their work; candidate demonstrates consideration of ethical issues in their design; candidate will include evidence of selected and detailed research using correct punctuation and grammar with detailed referencing of all sources used. **[6]**	
	Candidate will record data relating to their design and display the data; candidate will show some processing of their data; **[0 1 2]**	candidate will record precisely relevant data and display the scientific data accurately in a range of ways using tables simple graphs; candidate will show processing of their data; **[3 4 5]**	candidate will record precisely a detailed data set; candidate will display the scientific data accurately in a range of ways; candidate will collect sufficient data to complete simple statistics on the results. **[6]**	
	Candidate will offer a basic interpretation of the results and draw a basic conclusion; **[0 1 2]**	candidate will interpret the results and draw basic conclusions, explaining their results clearly, making real-life application wherever appropriate; **[3]**	candidate will interpret the results in detail using secondary sources to support their findings and draw conclusions relating to their results. **[4 5]**	
	Candidate will offer a basic evaluation of their work; **[0 1]**	candidate will provide examples of how their work could be improved upon and whether their chosen method is the most suitable, identifying advantages and limitations; **[2 3]**	candidate will provide practical and clinical analogies wherever appropriate and discuss how their experimental design could be modified using other existing methods and suggestions for further research. **[4]**	**/26**
			Total mark awarded:	**/50**

Unit G633 - Assessment Evidence Grid

Unit G633: Ecology and managing the environment

What the candidate needs to do:

The candidate needs to produce evidence of their investigation on ecology and managing ecosystems [**50** marks].

This evidence needs to include**:**

AO1: a knowledge and understanding of the effects of change on ecosystems and biodiversity, describing ecological succession and researching the effects of agricultural practice, human habitation and greenhouse gas production [**10**];

AO2: a discussion of the reasons for preserving ecosystems and biodiversity, describing the methods available to do this, and carrying out a study and evaluation of the methods used to manage an ecosystem [**14**];

AO3: a planned investigation of an ecosystem [**26**].

How the candidate will be assessed:

Assessment Objective	Mark Band 1	Mark Band 2	Mark Band 3	Mark Awarded
AO1	Candidate will demonstrate a basic knowledge and understanding of the relationship between the organisms, their physical environment and each other in ecological succession; **[0 1]**	candidate will demonstrate a sound knowledge and understanding of the relationship between the organisms, their physical environment and each other in ecological succession; candidate will use appropriate scientific terms and conventions accurately; **[2 3]**	candidate will demonstrate a thorough knowledge and understanding of the relationship between the organisms, their physical environment and each other in ecological succession; candidate will use appropriate scientific terms and conventions accurately. **[4 5]**	**/10**
	Candidate will research the effect of agricultural practice, human habitation and greenhouse gas production on ecosystems and biodiversity, selecting information and presenting it clearly, using correct spelling, punctuation and grammar; **[0 1]**	candidate will research the effect of agricultural practice, human habitation and greenhouse gas production on ecosystems and biodiversity, selecting a wide range of information, giving reasons for their choice of resources, and presenting it clearly and logically, generally using correct spelling, punctuation and grammar; **[2 3]**	candidate will research the effect of agricultural practice, human habitation and greenhouse gas production on ecosystems and biodiversity, selecting a wide range of relevant information and presenting it clearly and logically, using correct spelling, punctuation and grammar throughout; candidate will evaluate the information available and justify the choice that they have included. **[4 5]**	

Unit G633: Ecology and managing the environment (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO2	Candidate will identify some of the scientific, moral and ethical reasons for preserving ecosystems and species diversity; **[0 1]**	candidate will identify and explain the scientific, moral and ethical reasons for preserving ecosystems and species diversity; **[2 3]**	candidate will organise information to evaluate the scientific, moral and ethical reasons for preserving ecosystems and species diversity. **[4]**	**/14**
	Candidate will describe some of the methods used to manage ecosystems and preserve species diversity; candidate will give a limited interpretation of information relating to the success of a project managing **one** ecosystem; **[0 1]**	candidate will describe methods used to manage ecosystems and preserve species diversity; candidate will describe and interpret data relating to the success of a project managing **one** ecosystem; **[2 3]**	candidate will describe a range of methods used to manage ecosystems and preserve species diversity; candidate will interpret, explain and evaluate a range of data relating to the success of a project managing **one** ecosystem. **[4 5]**	
	Candidate will carry out straightforward calculations on ecological data (e.g. mean, standard deviation) and will sometimes obtain the correct solutions; **[0 1]**	candidate will carry out complex calculations on ecological data, involving some use of statistics (e.g. diversity indices) and obtaining the correct solutions; **[2 3]**	candidate will carry out complex calculations on ecological data involving the statistical analysis of the data obtained (e.g. chi-squared or t test); candidate will obtain the correct solutions to an appropriate degree of accuracy and demonstrate an understanding of the significance of the outcomes. **[4 5]**	

Unit G633: Ecology and managing the environment (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO3	Candidate will produce risk assessments; candidate will carry out measurements of some factors affecting the ecosystem that the candidate studied, using a range of techniques and equipment; **[0 1 2 3 4]**	candidate will produce risk assessments, consistent with COSHH guidelines; candidate will carry out measurements of factors affecting the ecosystem that the candidate studied, using a range of techniques and equipment; candidate will have repeated measurements, working with an appropriate degree of accuracy; **[5 6]**	candidate will produce their own detailed risk assessments, consistent with COSHH guidelines; candidate will carry out measurements of a wide range of factors affecting the ecosystem that the candidate studied and explain why they used a range of techniques and equipment; candidate will explain the need to have repeated measurements, and work with an appropriate degree of accuracy. **[7 8]**	
	Candidate will make and record relevant observations and measurements in the ecosystem; **[0 1 2]**	candidate will make and record relevant observations and measurements in the ecosystem, using precision in their measurements; **[3 4]**	candidate will make and record a detailed set of relevant observations and measurements in the ecosystem, using the appropriate precision in their measurements. **[5 6]**	
	Candidate will display the ecological data obtained using tables, with help; **[0 1]**	candidate will display the ecological data accurately in a range of ways; **[2 3]**	candidate will process and display accurately ecological data in a range of ways chosen to best illustrate the trends in the data. **[4]**	
	Candidate will give some interpretation of the results and relate these to the occurrence and distribution of species within the ecosystem studied; **[0 1 2 3 4]**	candidate will interpret the results, and draw basic conclusions, relating their results to the occurrence and distribution of species within the ecosystem studied; **[5 6]**	candidate will interpret the results in detail, and draw conclusions relating their results to the occurrence and distribution of species within the ecosystem studied. **[7 8]**	**/26**
			Total mark awarded:	**/50**

Unit G634 - Assessment Evidence Grid

Unit G634: Applications of biotechnology

What the candidate needs to do:

The candidate needs to produce evidence of their investigation into the use of biotechnology to solve agricultural, medical and industrial problems [**50** marks].

This evidence needs to include**:**

AO1: the production of a public information booklet to include information on the science of genetic engineering and the use of recombinant DNA technology in medicine **or** agriculture [**10**];

AO2: an evaluation of the effectiveness of techniques, benefits and impact on society of the production of genetically modified food plants, including evidence of associated calculations linked either to their research or practical work, consideration of the moral and ethical issues and the impact of legislation associated with the production of genetically modified food plants [**14**];

AO3: a practical investigation into enzyme technology, to include construction of a simple bioreactor and the effect of temperature on enzyme activity [**26**].

How the candidate will be assessed:

Assessment Objective	Mark Band 1	Mark Band 2	Mark Band 3	Mark Awarded
AO1	Candidate will produce a clearly presented booklet about the science of genetic engineering; **[0 1 2]**	candidate will produce a researched, detailed booklet about the science of genetic engineering with relevant information selected that is clearly and logically presented; **[3]**	candidate will produce a booklet about the science of genetic engineering, based on thorough research, with evidence that relevant information has been selected from a variety of sources, that is clearly and logically presented. **[4 5]**	**/10**
	Candidate will produce a clearly presented booklet about the use of recombinant DNA technology in medicine **or** agriculture with evidence of corrected punctuation and grammar; **[0 1 2]**	candidate will produce a researched, detailed booklet about the use of recombinant DNA technology in medicine **or** agriculture with relevant information selected that is clearly and logically presented with correct punctuation and grammar; **[3]**	candidate will produce a booklet about the use of recombinant DNA technology in medicine **or** agriculture, based on thorough research, with evidence that relevant information has been selected from a variety of sources, that is clearly and logically presented with correct spelling, punctuation and grammar. **[4 5]**	

Unit G634: Applications of biotechnology (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO2	Candidate will describe how successful recombinant DNA technology is in solving problems associated with food production by crop plants and come to a simple conclusion on the overall benefits of the technology; **[0 1 2]**	candidate will describe how successful recombinant DNA technology is in solving problems associated with food production by crop plants and come to a conclusion based on clear evidence; some evidence of evaluation of at least **two** specific examples of the technology is needed; **[3]**	candidate will produce a comprehensive evaluation of the success of specific examples of the production of genetically modified plants; there will be clearly referenced evidence for their case and a summary of their main findings. **[4 5]**	
	Candidate will demonstrate the completion of straightforward calculations either related to their research or to their practical investigations; some assistance may have been used; **[0 1]**	candidate will demonstrate the completion of straightforward and complex calculations either related to their research or to their practical investigations including some simple calculations on rates of reaction; limited assistance may have been used; **[2]**	candidate will demonstrate the independent completion of complex calculations either related to their research or to their practical investigations. **[3]**	
	Candidate will carry out a simple analysis of the moral and ethical case for **one** aspect of using recombinant DNA technology in the production of GM plants and explain **one** of the controls placed on scientists working in this field, using some relevant evidence; **[0 1 2]**	candidate will summarise some of the moral, ethical and environmental issues concerning the use of recombinant DNA technology in the production of GM plants; candidate will need to explain **two** types of controls placed on scientists that work in this field; **[3 4]**	candidate will explain fluently what he/ she considers to be the main moral, ethical and environmental issues concerning the use of recombinant DNA technology in the production of GM plants; candidate will need to evaluate **two** types of controls placed on scientists that work in this field for how effective they are. **[5 6]**	**/14**

Unit G634: Applications of biotechnology (continued)				
Assessment Objective	**Mark Band 1**	**Mark Band 2**	**Mark Band 3**	**Mark Awarded**
AO3	Candidate will plan their practical work with help, including risk assessments; candidate will construct a simple reactor and be able to produce and use an immobilised enzyme; **[0 1 2]**	candidate will produce a clear plan with limited help which includes risk assessments consistent with COSHH guidelines; **[3]**	candidate will produce a clear plan of action of their own, including detailed risk assessments consistent with COSHH guidelines, using secondary sources. **[4 5]**	
	Candidate will carry out measurements from the reactor, with help; candidate will use a range of techniques and equipment; **[0 1 2]**	candidate will carry out measurements from the constructed bioreactor using an immobilised enzyme system; candidate will use a range of techniques and equipment and have repeated measurements, working with an appropriate degree of accuracy; **[3]**	candidate will carry out measurements from the constructed bioreactor, using an immobilised enzyme system, on factors affecting their bioreactor; candidate will explain the use of a range of techniques and equipment and will have repeated measurements when appropriate; candidate will work with an appropriate degree of accuracy. **[4 5]**	
	Candidate will make and record relevant observations and measurements on the effect of temperature on the constructed bioreactor, with help; candidate will display the data obtained using tables and simple graphs, with help; candidate will show some processing of their data; **[0 1 2 3]**	candidate will make and record relevant observations and measurements on both the bioreactor and the immobilised enzymes, using precision in their measurements; candidate will display the scientific data accurately in a range of ways; candidate will show accurate processing of their data; **[4 5 6 7]**	candidate will make and record a detailed set of relevant observations with limited help, using the appropriate precision in their measurements; candidate will display the scientific data accurately in a range of ways, and process them in a manner chosen to best illustrate the trends in data; candidate will collect sufficient data to complete simple statistics on the results. **[8 9]**	
	Candidate will give some interpretation of the results and relate these to how enzymes work and enzyme immobilisation; candidate will include a basic evaluation; **[0 1 2]**	candidate will interpret the results and draw basic conclusions relating their results to how enzymes work, the advantages of using bioreactors and enzyme immobilisation; candidate will evaluate their investigation and results; **[3 4 5]**	candidate will interpret the results in detail using secondary sources to support their findings; candidate will draw conclusions relating their results to the use of bioreactors and enzyme immobilisation, specifying named examples in either medicine or industry; candidate will discuss the significance of their findings in terms of how enzymes work, fully evaluating their work. **[6 7]**	**/26**
			Total mark awarded:	**/50**

Appendix C: Mathematical Requirements

This appendix provides general guidance on the range of mathematical skills that candidates may be expected to use during a course in GCE in Applied Science. Candidates need to demonstrate these skills, where appropriate, in their portfolio work for internally-assessed units, and questions in the written papers for externally-assessed units may require their use.

In addition to these general skills, specific mathematical requirements for individual units, e.g. the use of statistical techniques, or particular formulae or equations, are given in the units themselves and will form part of the assessment of these units.

Arithmetic and computation

Candidates should be able to:

- recognise and use expressions in decimal and standard form;
- use ratios, fractions and percentages;
- make estimates of the results of calculations (without using a calculator);
- use calculators to find and use x^2, $\frac{1}{x}$, $\sqrt{x}$.

Handling data

Candidates should be able to:

- use an appropriate number of significant figures;
- find arithmetic means;
- construct and interpret bar charts, pie charts and histograms.

Algebra

Candidates should be able to:

- understand and use the following symbols: $<$, $>$, $\approx$; $\propto$
- understand and use the prefixes: giga (G), mega (M), kilo (k), milli (m), micro (μ), nano (n);
- change the subject of an equation;
- substitute numerical values into algebraic equations using appropriate units for physical quantities.

Graphs

Candidates should be able to:

- translate information between graphical, numerical and algebraic forms;
- plot and interpret graphs of two variables from experimental or other data.

Calculations

There are references in the *Assessment Evidence Grids* to 'straightforward' and 'complex' calculations.

Straightforward calculations

Generally these have **one** or **two** steps, for example:

- percentages;
- percentage increases;
- mean;
- mode;
- range;
- calculations involving 1:1 ratios (volumetric analysis);
- simple substitution into straightforward equations without rearrangement, e.g. $F = ma$ to find F;
- gradients of straight-line graphs.

Complex calculations

Generally these have **two** or more steps, for example:

- percentages;
- percentage increases;
- mean;
- mode;
- calculations involving ratios more complex than 1:1 ratios, e.g. 1:2, 2:5;
- statistical analysis, e.g. chi-squared or t-test, calculation of standard deviation;
- substitution into equations with rearrangement or use of powers or standard form (giving answers to appropriate numbers of significant figures);
- gradients of curves (tangents) and use of gradients in equations of the form $y = mx + c$.

Appendix D: Health and Safety

Useful information can be found at www.cleapss.org.uk

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

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

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

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

- *Topics in Safety*, 3rd edition, 2001, ASE ISBN 0 86357 316 9;
- *Safeguards in the School Laboratory*, 11th edition, 2006, ASE ISBN 978 0 86357 408 5;
- CLEAPSS® *Hazcards*, 2007 edition and later updates*;
- CLEAPSS® *Laboratory Handbook**;
- *Hazardous Chemicals*, A Manual for Science Education, 1997, SSERC Limited

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

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

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

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

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