GCSE

Applied Science (Double Award)

OCR GCSE in Applied Science (Double Award) J649

Section 6.6 has been updated (amended in Oct 2007).

QAN 100/5631/2

Contents

1 About this Qualification

1.1 About this Applied Science (Double Award) Specification

This booklet contains OCR's GCSE specification in Applied Science (Double Award) for teaching from September 2006 and first certification in June 2008.

The specification builds upon the broad educational framework set out in the criteria for GCSEs in vocational subjects from the Qualifications and Curriculum Authority. GCSEs in vocational subjects are broad based vocational qualifications designed to widen participation in vocationally-related learning pre-16 and to encourage post-16 candidates to try a vocationally-related course where maybe another programme has previously not proved appropriate for them.

The GCSE in Applied Science (Double Award) has been designed to form a qualification which provides the technical knowledge, skills and understanding associated with the subject at these levels so as to equip candidates with some of the skills they will need in the workplace or in further education or training. It allows candidates to experience vocationally-related learning so as to enable them to decide if it is suitable for them.

A GCSE in Applied Science (Double Award) is an ideal qualification for those candidates who want a broad background in science and the course of study prescribed by this specification can reasonably be undertaken by candidates entering this vocational area for the first time. It is designed to enable candidates to make valid personal choices upon completion of the qualification and to progress to further education, training or employment. It provides a suitable basis for further study in this subject or for related courses which could include GCE, NVQ or Modern Apprenticeship. It is designed to be delivered in full-time or part-time education.

Examples of appropriate employment to which a GCSE in Applied Science (Double Award) candidate might progress include: medical technicians, pharmaceutical technicians, laboratory technicians, in industry, service sectors or education.

The fundamental philosophy of this specification is that, in order to understand the nature of applied science, candidates must actively experience science in a work place environment. This can be achieved through a variety of approaches including work experience, links with local employers and research establishments, case studies and research.

The GCSE in Applied Science (Double Award) has been designed to provide a range of teaching, learning and assessment styles to motivate candidates to achieve the best they can and to empower them to take charge of their own learning and development. Assessment is designed to give credit for what candidates can do as well as what they know. It is based both on portfolio evidence from assignments, set and assessed by the centre and moderated by OCR, and an external assessment, which is set and marked by OCR. The content of the externally assessed unit may be taught through activities used in the portfolio units.

This specification is supported by users as well as a range of professional institutes and Further and Higher Education Institutions.

This specification is assessed through three mandatory units.

Unit	Unit Code	Title	Duration	Weighting	Total Mark
1	B481	Developing Scientific Skills	-	33⅓	50
2	B482	Science for the Needs of Society	1 hour	33⅓	60
3	B483	Science at Work	-	33⅓	50

1.2 Qualification Title and Levels

This qualification is shown on a certificate as OCR GCSE in Applied Science (Double Award).

This qualification is approved by the regulatory authorities (QCA, ACCAC and CEA) as part of the National Qualifications Framework (NQF).

Candidates who gain grades GG to DD will have achieved an award at Foundation Level (Level 1 of the NQF).

Candidates who gain grades CC to A*A* will have achieved an award at Intermediate Level (Level 2 of the NQF).

This qualification is of a standard which is broadly equivalent to two GCSEs at grades G to A*.

1.3 Aims

GCSE in Applied Science (Double Award) specifications should enable candidates to develop a broad knowledge and understanding of the science sector. They should prepare candidates for further study on a vocational course in science or in a science-related subject or prepare for employment or further training in the industry. They should encourage candidates to develop:

- the ability to apply skills knowledge and understanding of how science works and its essential role in society;
- an awareness of how institutions and companies use science in a wide range of essential functions;
- the ability to apply knowledge and skills to solving scientific problems in a variety of vocational contexts;

1.4 Prior Learning/Attainment

Candidates entering this course should have achieved a general educational level equivalent to Entry Level 3 in the National Qualifications Framework, or Level 3 of the National Curriculum.

Prior learning, skills and aptitudes particularly relevant include:

- basic proficiency in literacy;
- basic proficiency in numeracy;
- some aptitude for ICT;
- some motivation to work independently.

2 Summary of Content

Unit 1: Developing Scientific Skills (B481)

- Working Safely in Science
- Carry Out Practical Tasks
- Investigating Living Organisms
- Chemical Analysis
- Investigating Materials

Unit 2: Science for the Needs of Society (B482)

- Living Organisms
- Humans as Living Organisms
- Obtaining Useful Chemicals
- Chemical and Material Behaviour
- The importance of Energy, Electricity and Radiation
- The Earth and Universe

Unit 3: Science at Work (B483)

- Science in the Workplace
- Making Useful Products
- Electronic and Optical Devices
- Mechanical Devices
- Monitoring Living Organisms

3 Units

Layout of Units

Units will have some or all of the following sections:

About this unit

This includes a brief description for the candidate of the content, purpose and vocational relevance of the unit. It states whether the unit is assessed externally or through portfolio evidence.

What you need to learn

This specifies the underpinning knowledge, skills and understanding candidates need to apply in order to meet the requirements of the portfolio evidence or external assessment.

Assessment evidence

This specifies the evidence candidates need to produce in order to meet the requirements of each portfolio unit. It is divided into the following parts:

You need to produce – this banner heading sets the context for providing the evidence, e.g. a report, an investigation, etc;

A typical candidate at grades GG to EE etc. will: – this describes the quality of the work a candidate needs to demonstrate in order to achieve the grades specified.

Guidance for teachers

This provides advice on teaching and assessment strategies.

There will be advice on:

- the provision of the vocational context of the unit;
- accurate and consistent interpretation of national standards;
- the use of appropriate internal assessments, taking into account the full range of grades to be covered.

There may also be advice on:

- exploiting local opportunities (e.g. information sources, events, work experience);
- resources.

Key Skills guidance

This signposts opportunities for developing and assessing Key Skills within the unit.

UNIT 1: DEVELOPING SCIENTIFIC SKILLS

About this Unit

In this unit you will learn about the skills needed to carry out experiments and work in the laboratory. You will learn about:

- working safely in science;
- carrying out practical tasks, involving the following skills:
    - following standard procedures;
    - handling scientific equipment and materials;
    - recording and maximising scientific data;

  in the areas of:

    - investigating living organisms;
    - chemical analysis;
    - investigating materials.

Scientists classify things (e.g. materials and organisms), obtain or make things (e.g. making chemical products, building electronic devices, obtaining products from organisms) and monitor and control changes (e.g. chemical reactions, the performance of machines or the activities of organisms). In their work, they use a wide range of materials and scientific equipment. They need to be able to work with scientific equipment, apparatus and materials correctly.

Scientists carry out experiments, making measurements and observations, either in a laboratory or in the field. They use a wide range of materials and equipment. Often they follow standard procedures. At other times, scientists have to devise procedures for themselves. Sometimes the unexpected happens and they have to deal with this.

The unit also links with units from other GCSEs in vocational subjects, such as *Engineering, Manufacturing and Health and Social Care* and with some NVQs, such as *Laboratory and Associated Technical Activities and Laboratory Technicians: Working in Education*. Level 2 NVQs are required as part of a Foundation Modern Apprenticeship.

*You should be **selective** and include in your portfolio only work, from this unit, that **meets the evidence requirements.***

This unit is assessed solely through portfolio assessment.

What You Need to Learn

Working Safely in Science

Scientific work can be dangerous, yet accidents among scientists are rare. This is because scientists are always aware of the hazards they deal with and of the need to work safely. You must be able to work safely and prevent accidents in the laboratory or wherever you are doing your scientific work. You must know what to do if an accident happens.

Hazards and Risks

Potential hazards in scientific workplaces include:

- careless behaviour;
- not using equipment properly;
- not using protective and safety equipment;
- not following correct procedures;
- the possible risks that may arise from:

chemical substances classified as toxic, flammable, corrosive, oxidising agent and irritant;

culturing organisms

utilities (gas and electricity).

It is important that you are aware that workplaces are governed by health and safety regulations.

You need to be able to:

- identify hazard warning signs;
- identify biological, chemical and physical hazards, including radioactive substances and their associated risks;
- follow health and safety procedures.

You need to be aware of the need to:

- carry out health and safety checks in the workplace;
- carry out risk assessments for activities performed in the workplace.

You need to find out:

- what can be done to prevent accidents from hazards in a scientific workplace;
- which emergency procedures to follow if an accident from these hazards happens; about the safety measures employed for handling radioactive materials and the procedures adopted to ensure that people who work with radioactive materials are not exposed to unacceptable risk;
- about how unwanted or waste materials, including radioactive substances, are disposed of safely.

First Aid

Common injuries in laboratories are heat burns and scalds, chemical burns, injury from breathing in fumes or swallowing chemicals, electric shock, cuts and damage to the eyes from particles or chemicals. For each of these injuries, you need to know:

- the basic first aid to give;
- the situations in which it would be dangerous to give first aid.

You need to find out:

- why it is useful to have a first aid qualification;
- the names of organisations which give training for first aid qualifications and how to contact these organisations

Fire Prevention

In places of work, including your school or college, there are fire regulations. These regulations are to ensure that the numbers of casualties in fires are kept to a minimum. Although many people are killed or injured in fires each year, the vast majority occur in the home and only 6% of deaths and 10% of injuries occur in the workplace (Fire Statistics United Kingdom 1999: L. Watson, J. Gamble and R. Schofield). However, continued vigilance is essential if these figures are to be maintained or improved.

You need to know:

- what must be done if you hear a fire alarm or smoke alarm;
- what must be done if you find a fire;
- how fire doors function;
- why different types of fire extinguishers (water, carbon dioxide, dry powder, foam, a fire-blanket) are used on different types of fires;
- about the use of automatic sprinkler systems.

Carrying out Practical Tasks

You will perform a range of practical tasks to develop the following skill areas.

Following Standard Procedures

Standard procedures provide explicit instructions on how to carry out an experiment. They are often called protocols or standard operating procedures. Their use means that when you see the results, you know exactly how the observations and measurements were made, no matter who did it or where it was done. For these reasons, standard procedures are very important in the scientific workplace. The procedure may be to carry out measurements, to prepare and purify a compound or to monitor a change. Standard procedures may be agreed within a company or nationally or internationally.

When following a standard procedure, you need to be able to:

- read the procedure and check to see if there is anything you do not understand;
- carry out a health and safety check of your working area;
- carry out a risk assessment for the activity you are doing;
- set out your work area and collect together the equipment and materials you need;
- follow the instructions one step at a time;
- make accurate observations or measurements, selecting instruments which give the appropriate precision;
- identify possible sources of error and repeat observations and measurements, when necessary, to improve reliability.

Handling Scientific Equipment and Materials

There are certain practical skills that scientists carry out every day and practicing them will help to improve your accuracy and build your confidence. It will also help you to use other, less familiar, equipment and materials. You will need to become familiar with general laboratory equipment and to carry out general operations carefully and accurately.

You need to know how to:

- select and use the standard laboratory equipment and glassware provided;
- select and prepare equipment safely for use, including data logging equipment where appropriate;
- calibrate instruments, when necessary.

Recording and Analysing Scientific Data

Standard procedures usually tell you how to obtain and record observations and measurements and what to do with them. However, you should know some basic methods for recording and presenting data and for carrying out calculations. ICT should be used, where appropriate, in this work. It is also important that you think about the results you obtain and are able to interpret them.

You need to be able to:

- present data in tables, bar charts, histograms, pictograms, pie charts, graphs and other visual images, as appropriate;
- carry out simple numerical calculations;
- analyse and interpret your results;
- evaluate your investigation and suggest improvements.

Your practical tasks will be in the following broad areas of science: Investigating Living Organisms, Chemical Analysis and Investigating Materials.

Investigating Living Organisms

Scientists study living organisms to learn more about how they are composed, how they function and the way they behave. In their investigations of living organisms, they use standard equipment and techniques.

Microscopy

Investigating living organisms provides a range of challenges for scientists. Some of these challenges are to do with the small size of the organism. Some organisms are too small to be seen by the human eye. To solve these problems, scientists use microscopes. Microscopes are also used to study cells and tissues that make up living organisms.

You need to be able to:

- set up a light microscope ready to use, choosing a suitable objective lens for the task;
- prepare samples for investigation, including making a temporary slide, using a staining technique.

Culturing organisms

Scientists have developed the use of microorganisms to greatly benefit society. Their uses include the production of bread, beer, wine, yogurt and antibiotics. There are also microorganisms that cause harm to us, or to plants and animals, which are important to us. Therefore, these need to be handled carefully when used.

Microorganisms are found on our hands, on the laboratory bench and almost everywhere. If scientists need to isolate a single type of microorganism, they need to make sure contamination from other microorganisms does not occur. They also need to avoid handling the organisms directly, as this may be dangerous. Using aseptic techniques ensures that both of these needs are fulfilled.

As well as microorganisms, scientists also culture cells. In some instances they grow these to produce new organisms, for instance when requiring identical plants. They also use this cloning technique when they grow plants from cells that have been genetically manipulated. Scientists clone animal cells for research purposes e.g. stem cells, or for use in grafts and transplants.

You need to:

- understand the importance of aseptic techniques to use them to culture organisms and dispose of them safely e.g. production of a food substance, cloning a plant, testing antimicrobial agents.

Chemical Analysis

Analytical chemists need to be able to test for the presence of certain chemical compounds in substances and determine their concentration in solutions. This may be to find out what is present in a sample or to test the purity of a substance or to detect the presence of pollutants (e.g. in river water), banned substances (e.g. in athletes) or alcohol (e.g. in those suspected of drinking and driving). Analysis is an important aspect of the work of the forensic scientist, both chemical and spectroscopic methods are important.

Qualitative Analysis

The analytical chemist may simply need to find out which substances are present. This process is known as qualitative analysis.

You need to:

- use chromatography to determine composition;
- detect Na^{+}, K^{+}, Ca^{2+}, Cu^{2+}, Pb^{2+}, Fe^{3+}, Cl-, SO_4^{2-}, CO_3^{2-} ions using reagents and/or flame tests;
- detect alcohol using acidified potassium dichromate solution and reducing sugars using Benedict's solution;
- interpret spectra to identify the presence of functional groups/compounds in forensic analysis;
- draw conclusions from your results.

Quantitative Analysis

Scientists may need to find out how much of a substance is present. This process is known as quantitative analysis.

You need to:

- prepare solutions of specified concentrations using the units: g dm^{-3} and mol dm^{-3};
- carry out titrations;
- carry out suitable calculations.

Investigating Materials

When scientists investigate the way in which materials behave, they may need to take measurements of certain physical properties. In deciding which material to use for a purpose, we may need to take account of more than one property. The size and shape of the material used may also be important.

Electrical Properties

Electrical and electronic circuits use a wide range of materials. The different properties of materials are exploited to perform different functions. Many household appliances, such as electric heaters, hairdryers and toasters use a high resistance wire in their elements so that heat is given out.

You need to investigate how:

- the nature, length and thickness of materials influence electrical resistance;
- current varies with voltage in a range of devices.

Other Physical Properties

Electrical properties are not the only properties a materials scientist has to consider. For example, if you were asked to select materials to build a house, some of the material properties you would consider would be thermal conductivity, density and strength.

You need to compare:

- the thermal conductivities of a range of materials;
- the densities of a range of materials;
- the strengths of materials of different size, shape and composition.

Assessment Evidence for Unit 1: Developing Scientific Skills

You need to produce a laboratory notebook or file in which you have written:

a a report on research into working safely in science, including hazards and risks, first aid and fire prevention [12 marks].

Your laboratory notebook or file also needs to include records of six practical activities* where in each activity you have shown you can:

b carry out risk assessments [6 marks];

c follow standard procedures involved in practical tasks using scientific equipment and materials [8 marks];

d make and record observations and/or measurements, present and process data [12 marks];

e draw conclusions and evaluate data [12 marks].

*These practical activities must be in each of the following areas: microscopy; microorganisms; qualitative analysis; quantitative analysis; electrical properties and other physical properties.

A typical candidate at grades GG, FF, EE will:	A typical candidate at grades DE to BC will:	A typical candidate at grades BB, AA, A*A* will:	Mark	Max
a1 Carry out research into working safely, using a limited range of sources and information, including: • hazards and risks; • first aid; • fire prevention. Report shows little structure or follows a structure provided by worksheet(s).	a2 Carry out research into working safely, using a range of sources and information, including: • hazards and risks; • first aid; • fire prevention. Report has an appropriate sequence and uses relevant visual and textual material	a3 Carry out research into working safely, using a wide range of sources and information, including: • hazards and risks; • first aid; • fire prevention. Report is logical, well sequenced with good justification and uses well chosen textual and visual material.		**12**
b1 For each practical activity: • produce an appropriate risk assessment with guidance.	b2 For each practical activity: • produce an appropriate risk assessment with some guidance.	b3 For each practical activity: • produce an appropriate and full risk assessment given little guidance.		**6**

c1 For each practical activity: • follow step by step instructions, with guidance; • use given, standard laboratory equipment correctly and safely with guidance.	c2 For each practical activity: • carefully follow instructions, with some guidance for the more complex tasks; • use appropriate laboratory equipment correctly and safely throughout each task.	c3 For each practical activity: • confidently follow standard procedure instructions, with little guidance in all tasks; • where appropriate select suitable laboratory equipment and confidently use correctly and safely.	**8**
d1 For each practical activity, where appropriate: • make and record simple observations and/or measurements with guidance; • present data in charts, graphs or visual images with guidance.	d2 For each practical activity, where appropriate: • make and record accurate observations and/or measurements independently; • recognise when it is necessary to repeat observations and/or measurements; • process data with some guidance and present in an appropriate format.	d3 For each practical activity, where appropriate: • make and record sufficient accurate observations and/or measurements independently; • repeat observations and/or measurements explaining why these were repeated; • independently process and correctly display data in a clear and appropriate way using a suitable format.	**12**
e1 For the data collected: • describe your findings; • identify a weakness(es) in the method used.	e2 For the data collected: • explain findings using simple scientific knowledge; • describe the weakness(es) of the methods used.	e3 For the data collected: • explain findings using detailed scientific knowledge and understanding; • review your work, identifying sources of error and suggesting improvements to their methods.	**12**
Note: Although you will be given an interim mark out of 50 by your teacher, this might be adjusted by OCR to make sure that your mark is in line with national standards.		**Total**	**50**

Guidance for Teachers

Guidance on Delivery

This unit develops the practical skills required for the work carried out in Unit 3: Science at Work. It is best taught concurrently with Unit 2: Science for the Needs of Society.

In Unit 3, candidates will examine how scientific knowledge and understanding, along with underpinning practical skills are applied, both in the school and college laboratory and in the workplace. It is best delivered, therefore, integrated with the other two units, and using Unit 2 as the focal point. For example:

Unit 2 topic: Microorganisms

Unit 2 content	Unit 1 content	Unit 3 content
Cell theory	Microscopy: Examination of yeast cells	Monitoring the activity of yeast How science is used in a brewery
Useful microorganisms Fermentation	Culturing organisms: Aseptic culture of yeast Producing a food product	

Unit 2 topic: Chemical manufacture

Unit 2 content	Unit 1 content	Unit 3 content
Classify chemical compounds	Tests for cations and anions	
Identify examples of bulk and fine chemicals fertilizers pigments medicines	Separating dyes using chromatography	Laboratory preparation of: Ammonium sulfate Zinc oxide Iron (II) sulfate

Unit 2 topic: Metals

Unit 2 content	Unit 1 content	Unit 3 content
Properties of metals Relate structure to properties	Suitability of different metals for electrical cables Electrical properties of materials	The generation of electricity and the power station
Links with the generation of electricity	Other physical properties (tensile strength, thermal conduction)	

In delivering this unit, due consideration must be made to the balance of the appropriate assessment objectives:

Assessment objective	Balance
AO1: Knowledge and understanding of science and how science works	10%
AO2: Application of skills, knowledge and understanding	35%
AO3: Practical, enquiry and data-handling skills	55%

Note that in strands b, c, d and e, elements of planning are required for candidates working towards Mark Band 3. Candidates operating at lower mark bands will follow instructions to carry out practical activities.

When carrying out work in this unit, appropriate emphasis should be placed on developing vocational contexts. For example:

Chemical activities

- Chromatography – identification of unknown substances by comparison as in forensic investigations.
- Testing for the presence of ions – laboratory testing for water pollution.
- Carry out titrations – laboratory preparation/manufacture of economically important compounds, e.g. ammonium sulphate for fertilizer industry.

Physical activities

- Electrical properties of different materials – monitoring and control, e.g. medical equipment, security devices such as fire alarms and thermostats.
- Thermal conductivity, density and strengths of materials – the building of structures, e.g. ship, house or bridge.

Biological activities

- Microscopy – pathology in a hospital lab, examining cells. Brewing industry, checking for plant pests in horticulture.
- Microorganisms – culturing yeast for beer production *(Saccharomyces cerevisiae)* or yogurt *(Streptococcus thermophilus* and *Lactobacillus bulgaricus)* fermentation. Identifying pathogens in a public health laboratory. Note: pathogens should not be cultured as a practical activity within normal laboratory conditions.

Forensic Science can be used to introduce:

- laboratory testing of unknown compounds;

identification of +ve ions in flame tests;

identification of –ve ions in solution;

- chromatography and matching techniques;
- microscopy techniques.

Food Investigative Work and Trading Standards

This vocational context can be used for work in:

- vinegar dilution can be used as an example for titration work;
- chromatography can be used to identify colourings used in foods and confectionery;
- the use of micro-organisms can be linked to the production of foods.

Work Linked to Agriculture and Horticulture

- The composition of fertilisers can be used as an introduction to the identification of ions.
- The effectiveness of pesticides may be linked to titration work on concentration.
- The control of plant pests and diseases may be linked to microscope work.

Work on Materials

The focus may be on cars, motorbikes, sporting equipment, computer, cookers or similar, depending on the interest of the candidate.

Work in this area can be linked to any manufacturing industry such as vehicle, ceramics, computing.

Guidance on Assessment

Each portfolio should be marked by the teacher according to the criteria in the Assessment Evidence Grid on pages 16 and 17 (exemplification for which is given later in this section). Each row in the grid shows the hierarchical development of each criterion that makes up part of the strand. Each row corresponds to a point (a, b, c etc.) in the banner.

Please note that the second column describes the work of a typical candidate working at grades DE to BC whilst the third column describes the work of a typical candidate working at the upper half of grade BB, grades AA and A*A*.

Use your professional judgment to determine which criterion in a strand best suits the individual candidate's work using the amplification of criteria, pages 21 – 24, to help. The maximum mark for each strand is shown in the far right hand column of the grid. The mark for each strand is derived using guidance on the Awarding of Marks, pages 25 - 27.

Amplification of Criteria

Mark band	Amplification of Criteria
Strand a	**Working Safely in Science**
a1	Work presented includes some basic level information or research evidence on **Hazards and Risks** • potential hazards in the work place • hazard warning signs • some health and safety procedures **First Aid** • common injuries in the laboratory and what to do • basic first aid procedures **Fire Prevention** • basic instructions on fire procedures • information on fire extinguishers Work can be presented in the form of a report, or leaflet or presentation, or can included answers to worksheets related to the appropriate topics.
a2	Work presented at this level should include much more detailed information as well as coverage of more bullet points from this section. Work should show candidate's ability to select suitable work. **Hazards and Risks** • potential hazards in the work place to include information on • information on hazard warning signs and details on health & safety procedures • some health & safety procedures details **First Aid** • common injuries in the laboratory and what to do • basic first aid procedures (evidence that a suitable course has been taken can be used in this section) • information on first aid qualifications **Fire Prevention** • instructions on fire procedures • information on fire doors • information on fire extinguishers • the use of sprinklers Work can be presented in the form of a report, or leaflet or presentation with suitable illustrations. It should also be logical and have an appropriate sequence.
a3	Work presented at this level should include detailed information which includes full coverage of most of the bullet points above. **Hazards and Risks** **First Aid** **Fire Prevention** The work should be detailed and accurate. Work can be presented in the form of a report, or leaflet or presentation. Work should show candidate's ability to select suitable work, and be presented in a logical and well sequenced way. Candidates at this level should be showing evidence of independent working.

Strand b	Produce Risk Assessments
b1	Evidence of a basic knowledge of the hazards and risks involved in each practical procedure carried out. Candidates at this level can be given help in the completion of a basic risk assessment. Hazard What is risk How can we reduce the risks
b2	Guidelines can still be given to candidates and more details of hazards and risks need to be recorded Chemical/equipment Nature of Hazard Risk Control measures
b3	Full understanding of use of risk assessments and evidence of independent work in completing detailed risk assessments – proforma should still be used.

Strand c	Follow standard procedures involved in practical tasks using scientific equipment and materials
c1	Guidelines cover all six different practicals at this level. Suggest teacher indicates on candidates' work that: • step by step instructions have been followed with help; • standard laboratory equipment has been correctly and safely used with help. Candidates need complete practical activities using the guidelines as indicated in: • Investigating Living organisms (microscopy and culturing organisims); • Chemical Analysis (qualitative analysis and quantitative analysis); • Investigating materials (electrical properties and one other physical properties).
c2	Guidelines cover all six different practicals at this level. Suggest teacher indicates on candidates' work that: • instructions were carefully followed; • appropriate laboratory equipment has been correctly and safely used; • parts of the task was quite complex; • some/little guidance was given. The practical tasks at this level need to show some complex nature – use of burette, setting up circuits correctly /care in making a chromatogram correct aseptic technique etc. Candidates need complete practical activities using the guidelines as indicated in: • Investigating Living organisms (microscopy and culturing organisms); • Chemical Analysis (qualitative analysis and quantitative analysis); • Investigating materials (electrical properties and preferably 2 other physical properties).

c3	Guidelines cover all six different practicals at this level. Suggest teacher indicates on candidates' work that: • standard procedure instructions were confidently followed; • appropriate laboratory equipment has been correctly selected and safely used; • tasks were quite complex; • no guidance was needed/given. Again the practical tasks at this level need to show complex nature e.g. the use of a graduated pipette, using circuits correctly, producing a well prepared slide, using a more complex staining technique, use of a haemacytometer. Simple practical tasks will not allow achievement of mark band 3. Tasks should be extended to ensure that the higher level candidates are given opportunity to reach this level. Candidates need complete practical activities with less guidance than at level 2 using the guidelines as indicated in: • Investigating Living Organisms (microscopy and microorganisms); • Chemical Analysis (qualitative analysis and quantitative analysis); • Investigating materials (electrical properties and preferably 2 other physical properties).

Strand d	**Make and record observations and/or measurements, present and process data**
d1	Guidelines cover all six different practicals at this level. Candidates need to: • make and record simple observations/measurements using writing frames where required; • present data in simple charts and/or graphs, photographic, digital images using writing frames where appropriate. It would be useful if the teacher could indicate on the candidate's work the level of guidance given.
d2	Guidelines cover all six different practicals at this level. Candidates need to: • make and record accurate observations/measurements; • recognise when it is necessary to repeat observations and/or measurements; • process data and present the data in a suitable format. It would be useful if the teacher could indicate on the candidate's work the level of accuracy and the level of independence shown by the candidate
d3	Guidelines cover all six different practicals at this level. Candidates need to: • make and record sufficient accurate observations/measurements; • repeat observations and/or measurements with a suitable explanation; • manipulate and display data in a precise and appropriate way. It would be useful if the teacher could indicate on the candidate's work the level of accuracy and the level of independence shown by the candidate.

Strand e	Draw conclusions and evaluate data
e1	Guidelines cover all six different practicals at this level. For data collected candidates need to: • give simple descriptions of their findings; • simple identification of the weaknesses in the method they used e.g. difficulties in making measurements etc.
e2	Guidelines cover all six different practicals at this level. For data collected, candidates need to: • give explanations of their findings using simple scientific knowledge and understanding where appropriate e.g. a simple factual statement can be included as an explanation; • describe the weaknesses in the method they used and the effect they had on the data/observations produced.
e3	Guidelines cover all six different practicals at this level. For data collected, candidates need to: • give explanations of their findings using a full and detailed scientific knowledge and understanding e.g. the theory behind the experiment needs to be linked with their findings; • review their work, identifying any sources of error e.g. from experimental design, accuracy and precision of apparatus, random errors and suggesting any improvements to their methods. If experimental work was completely successful this needs to be stated.

Centres should use the full range of marks available to them. Centres must award full marks in any band for work which fully meets the criteria. This is work which is 'the best one could expect from candidates working at GCSE (Double Award) level.

Where some items are missing from the portfolio, the work should be referred back to the candidate for completion wherever possible. If this is not possible, the following actions should be taken:

Awarding of Marks

Strand a Working Safely in Science (12 marks)

A report on research into working safely in science including the following areas:

- Hazards and Risks
- First Aid
- Fire Prevention

Mark Band	
Band 3: 10-12 marks	12 marks for **three** areas at mark band 3 11 marks for **two** areas at mark band 3 (the other area at least mark 1) 10 marks for **one** area at mark band 3 (2 areas at least mark band 1)
Band 2: 7-9 marks	9 marks for **three** areas at least mark band 2 8 marks for **two** areas at least mark band 2 7 marks for **one** area at least mark band 2
Band 1: 0-6 marks	6 marks for **three** areas at mark band 1 3, 4, 5 marks for **two** areas at mark band 1 1, 2 marks for **one** area at mark band 1

Their portfolio of work needs to include records of six practical activities – one in each of the following:

- Microscopy
- Microorganisms
- Qualitative analysis
- Quantitative analysis
- Electrical properties
- Other physical properties

Strand b Produce Risk Assessments (6 marks)

Mark Band	
Band 3: 5-6 marks	6 marks for **six** completed risk assessments at mark band 3 5 marks for five or four completed risk assessments at mark band 3 (one at least mark band 1)
Band 2: 3-4 marks	4 marks for **six** completed risk assessments at mark band 2 3 marks for **three, four or five** completed risk assessments at mark band 2
Band 1: 0-2 marks	2 marks for **six** completed risk assessments at mark band 1 1 mark for **two, three, four or five** completed risk assessments at mark band 1

Strand c Follow Standard Procedures Involved in Practical Tasks Using Scientific Equipment and Materials	
Mark Band	
Band 3: 7-8marks	8 marks for **six** completed activities at mark band 3 7 marks for **four or five** completed activities at mark band 3
Band 2: 4-6 marks	6 marks for **five or six** completed activities at least mark band 2 5 marks for **four** completed activities at least mark band 2 4 marks for **three** completed activities at least mark band 2
Band 1: 0-3 marks	3 marks for **five or six** completed activities at least mark band 1 2 marks for **three, four completed** activities at least mark band 1 1 mark for **one, or two completed** activities at mark band 1

Strand d Make and record observations and/or measurements, present and process data	
Mark Band	
Band 3: 9-12marks	12 marks for **six** completed activities at mark band 3 11 marks for **five** completed activities at mark band 3 (the other activities at least mark band 1) 10 marks for **three or four** completed activities at mark band 3 (the other activities at least mark band 1) 9 marks for **one or two** completed activities at mark band 3 (the other activities at least mark band 1)
Band 2: 6-8 marks	8 marks for **five or six** completed activities at mark band 2 7 marks for **three or four** completed activities at mark band 2 6 marks for **one or two** completed activities at mark band 2
Band 1: 0-5 marks	5 marks for **six** completed activities at mark band 1 4 marks for **five** completed activities at mark band 1 3 marks for **three or four** completed activities at mark band 1 2 marks for **two** completed activities at mark band 1 1 mark for **one** completed activities at mark band 1

Strand e Draw conclusions and evaluate data	
Mark Band	
Band 3: 8-12marks	12 marks for **six** completed activities at mark band 3 11 marks for **five** completed activities at mark band 3 (other activities at least mark band 1) 10 marks for **three or four** completed activities at mark band 3 (other activities at least mark band 1) 9 marks for **two** completed activities at mark band 3 (other activities at least mark band 1) 8 marks for **one** completed activity at mark band 3 (other activities at least mark band 1)
Band 2: 5-7 marks	7 marks for **five or six** completed activities at mark band 2 6 marks for **three or four** completed activities at mark band 2 5 marks for **one or two** completed activities at mark band 2
Band 1: 0-4 marks	4 marks for **six** completed activities at mark band 1 3 marks for **five** completed activities at mark band 1 2 marks for **three or four** completed activities at mark band 1 1 marks for **one or two** completed activities at mark band 1

Recording of Marks

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.

The table below can be used to record the levels obtained for the different activities and then be used to calculate the total mark allocation for this unit.

	Strand a	**Strand b**	**Strand c**	**Strand d**	**Strand e**
Working safely report					
Microscopy					
Microorganisms					
Qualitative analysis					
Quantitative analysis					
Electrical properties					
Physical properties					
Mark allocation					

Resources

This specification is supported by OCR approved Heinemann Texts and exemplar materials available from OCR.

Information should be readily available from CD ROMS, the Internet and GCSE books. Multimedia Science School is a CD ROM from New Media Press Ltd. (www.new-media.co.uk)

General GCSE books include:

Pupil Researcher Initiative, Thinking about Evidence, Collins (www.CollinsEducation.com)
New Salters Science for GCSE, two texts, Year 10 and Year 11 (www.heinemann.co.uk)

Useful sources of information include:

Safety in Science Education, DfEE, (1996, ISBN 0 11 270915 X)
Laboratory Handbook, CLEAPSS School Science Service, 1989 with later additions
Hazcards, CLEAPSS School Science Service, 1995
Microbiology: an HMI Guide for Schools and FE, HMSO, ISBN 0 11 270578 2
Safeguards in the School Laboratory, ASE, 1996
British Standards
protocols and standard operating procedures from local organisations.

Science teachers should be familiar with the requirements of COSHH Regulations, with DfES memoranda on the use of plants and animals in schools and with regulations applying locally. For information contact science advisor/education department.

CLEAPSS guidelines gives detailed advice on microbiology, with suggestions for useful reference material.

The National Centre for Biotechnology Education at Reading has produced many information and advice booklets, including suggestions for investigations.

The Microbiology in Schools Advisory Committee has produced information and advice leaflets. They also can supply a list of professional microbiologists willing to give advice. Contact MISAC c/o SGM, Marlborough House, Basingstoke Road, Reading RG7 1AE.

The use of certain tools, particularly power tools, is governed by the Provision and Use of Work Equipment Regulations. Some information is given in the ASE booklet referred to above, but teachers may wish to consult colleagues in Engineering or Technology departments on safety issues to do with the use of workshop tools. If power tools are to be used, an important point to note is that tools bought in the High Street or from DIY outlets may not comply with regulations for tools to be used in workplaces.

UNIT 2: SCIENCE FOR THE NEEDS OF SOCIETY

About this Unit

Scientists carry out research to increase understanding of the world we live in. They have made many discoveries and tested scientific ideas over hundreds of years, many of which still improve our lives today. However, in spite of this research, there are some questions that science cannot currently answer, and findings made by scientists, and their interpretations of these findings, can often be controversial.

In this unit you will learn about the living organisms that people work with, chemical products and materials that scientists develop for our use, the importance of energy, electricity and radiation, and the Earth and Universe around us.

You will study six sections:

Section	
2.1	Living organisms
2.2	Humans as living organisms
2.3	Obtaining Useful Chemicals
2.4	Chemical and Material Behaviour
2.5	The Importance of Energy, Electricity and Radiation
2.6	The Earth and Universe

This unit is assessed solely through an externally set test. You will take one of two tiered papers covering the grades GG to CC (foundation tier) or DD to A*A* (higher tier).

What You Need to Learn

2.1 Living Organisms

We obtain many useful materials from living organisms. In order to maximize production by plants, animals and microorganisms, some scientists work to understand how living things function. The production of food and resources is now an exact science. This may have a major impact on our environment. It is important to be aware of these changes so that informed decisions can be made about the future of our planet.

In addition to the work you carry out in this section, in Unit 1: Developing Scientific Skills, you will learn how scientists culture organisms, and you will monitor a particular organism in Unit 3: Science at Work.

This section also links with Section: *Humans as Living Organisms.*

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2.1 LIVING ORGANISMS

2.1.1 Useful Products

Scientists are looking for new and improved products all the time.

You need to be able to:

- identify useful products that can be made from living things.

Foundation Tier only	Both Tiers	Higher Tier only
• state that many useful materials are made from, or by using, living things: o from plants, we get cotton, pigments for dyes; chemicals to make drugs; o from animals, we get leather, silk, wool; o we use microorganisms to produce foods and medicines;		
• state that fermentation is used in the brewing, baking and dairy industries; • describe fermentation in yeast as a process that converts sugar and water into alcohol and carbon dioxide; • know that fermentation is catalysed by enzymes found in yeast; • describe an enzyme as a biological catalyst.	• state the conditions needed for fermentation in yeast; • describe how enzymes are involved in the brewing, baking and dairy industries, and in penicillin production;	• explain why fermentation works better under certain conditions;
	• state the word equation for the fermentation of glucose: glucose → ethanol (alcohol) + carbon dioxide.	• state the balanced symbol equation for the fermentation of glucose.

2.1 LIVING ORGANISMS

2.1.2 Cells

Cells are the building blocks of all almost all organisms. Plant and animal scientists study cells and the processes that go on in cells to learn more about life itself.

Scientists called pathologists examine cells to look for harmful changes that can lead to diseases such as cancer. Other scientists culture cells that can be used for transplants and in techniques such as in-vitro fertilisation. Cutting edge, but controversial research on stem cells from human embryos may one day lead to the effective treatment of forms of diseases and injuries that are currently incurable.

You need to be able to:

- describe living things as being made up of the same types of chemical compounds;
- state that the cell is a common feature of (almost) all living things.

Foundation Tier only	Both Tiers	Higher Tier only
• recall that all living things are made up from cells;	• explain that all living organisms are made up from chemical compounds and that the cell is the basic unit of life;	• recall that all living organisms are made up of carbohydrates, proteins, lipids and nucleic acid;
• identify the parts of cells and their functions: o nucleus – carries genetic information; o membrane – controls movement of substances in and out of cells; o cytoplasm – where many chemical processes happen; o chloroplasts – absorb light energy for photosynthesis; o cell wall – provides support; o vacuole – contains cell sap and helps provide support;	• describe the similarities and differences between plant and animal cells: o nucleus, membrane, cytoplasm in plant and animal cells; o chloroplasts, cell wall, large, permanent vacuole in plant cells only;	• explain why viruses to not conform to this model;
• state that chromosomes are held in the nucleus and that they carry information in the form of genes.	• state that chromosomes are strings of genes which instruct each cell and determines how the organism functions.	• state that genes are made of a chemical called DNA which carries the genetic code.

2.1 LIVING ORGANISMS

2.1.3 Dividing Cells

Scientists study how cells divide. This is important when growing useful microorganisms such as yeast and when cloning important types of cells.

You need to:

- understand that cells divide by mitosis during growth;
- understand that cells divide by meiosis when producing gametes or sex cells.

Foundation Tier only	Both Tiers	Higher Tier only
	• explain that cell division is required for the growth of an organism;	• explain that in multicellular organisms, growth is a combination of cell enlargement and cell division;
	• describe the nucleus of a cell contains long thread-like structures called chromosomes; o know that during the growth of an organism, or when a cell is cloned, cells divide by mitosis; o know that to produce gametes, cells divide by meiosis.	• when a cell divides by mitosis, two daughter cells are produced, each with a set of chromosomes identical to parent cell; • explain the role of mitosis in cloning, and the scientific, moral, ethical issues of cloning human cells; • understand why meiosis is required to produce gametes (which contain half the normal number of chromosomes.

2.1 LIVING ORGANISMS

2.1.4 Producing food from plants

Plants are able to produce their own food by photosynthesis. We eat the food that they produce. Commercial growers of plants need to maximise the rate of photosynthesis of plants to get the best yields.

You need to be able to understand that plants:

- make food by photosynthesis;
- use respiration to release the energy they need to grow;
- need minerals for healthy growth.

Foundation Tier only	Both Tiers	Higher Tier only
• state that plants make glucose and starch by a process called photosynthesis; • state that plants need carbon dioxide, water, light and chlorophyll to carry out photosynthesis; • explain that glucose is converted and stored as starch; • state that photosynthesis occurs mainly in the leaves; • state that plants grow faster in the summer because of light and warmth;	• state the equation to describe photosynthesis: o carbon dioxide + water; o (+ light + chlorophyll); o → glucose + oxygen; • explain that the glucose made by photosynthesis is transported as soluble sugars but is stored as insoluble starch; • describe how photosynthesis can be increased by providing more CO_2; more light; a higher temperature;	• state the balanced symbol equation for photosynthesis: o $6CO_2 + 6H_2O$; o (+ light + chlorophyll); o $\rightarrow C_6H_{12}O_6 + 6O_2$; • explain the effects of limiting factors on the rate of photosynthesis (CO_2, light, temperature) and how crop scientists use this understanding to increase plant yields;
	• state that plants release energy by respiration: o starch is broken down; o oxygen is used from the air; o water and carbon dioxide are waste products;	• using data, explain how high rates of respiration can reduce plant yields;
• state that plants also need minerals, which are found in the soil, for healthy growth; • state that these minerals are absorbed in solution by the roots; • recall the names of important minerals; nitrates, phosphates, potassium and magnesium; • explain simple data about plant growth in the presence or absence of these minerals.	• state that plants require nitrates (for proteins which are needed for cell growth); magnesium (for chlorophyll); potassium (for healthy growth and flowering); phosphates (for healthy growth, including root growth); • explain and interpret data about plant growth in the presence or absence of these minerals;	• state that minerals are taken up into roots by active transport; • explain that active transport can move substances from low concentrations to high concentrations using energy from respiration;
	• explain how competition between plants for light can reduce crop yields.	• interpret data on research on factors affecting plant yields.

2.1 LIVING ORGANISMS

2.1.5 Farming Methods

Farmers who use intensive methods try to get maximum yields from their crops and farm animals. Organic farmers are concerned about the environmental impact of intensive methods.

You need to be able to:

- describe how intensive farming increases crop yields and meat and milk production but makes an impact on the environment;
- describe the methods used in organic farming and their impact on the environment;
- identify the benefits, drawbacks and risks of farming methods.

Foundation Tier only	Both Tiers	Higher Tier only
• explain why intensive farmers can produce more food if they use: o artificial fertilisers; o herbicides; o pesticides; o fungicides; o meat produced in controlled environments; • explain that these practices can cause harm to the environment and health.	• explain why intensive farming produces more food but: • excessive use of artificial fertilisers can cause damage to the environment (eutrophication) and be hazardous to health (nitrates in drinking water); • herbicides, pesticides and fungicides may enter and accumulate in the food chain; • intensive farming of animals raises ethical dilemmas.	• explain how intensive food production improves energy transfer by reducing energy transfer: o to competing plants; o to pests; o as heat from farm animals by keeping them indoors; • interpret data to explain why pesticides may accumulate in the food chain; • explain how scientific thinking has changed/is changing, and some innovations in intensive farming have now been abandoned (the low toxicity of DDT to humans, but the discovery of its accumulation in food chains; the suggested link between high protein animal feed and BSE/CJD).
• recall that organic farming uses alternative methods: o natural fertilisers; o mechanical elimination of weeds; o controlling pests biologically by introduced predators; o keeping animals under more normal conditions.	• explain how organic farming uses alternative methods but that productivity may be lower: o natural fertilisers; o mechanical elimination of weeds; o controlling weeds and pests using natural chemicals; o controlling pests biologically by introduced predators; o keeping animals under more humane conditions.	
• recall one advantage and one disadvantage of each type of farming.		• evaluate intensive and organic farming practices in terms of producing sufficient food to feed the world, effects on the environment, animal welfare and relative costs.

2.1 LIVING ORGANISMS

2.1.6 Ecology

Ecologists study the relationships between organisms and the environment. These relationships become disturbed when changes occur in the environment, often as a result of human activity.

You need to be able to:

- understand that organisms are interdependent;
- organisms that live successfully in a habitat are adapted to their environment;
- understand some of the effects of environmental change on organisms.

Foundation Tier only	Both Tiers	Higher Tier only
• be able to interpret food chains; • understand that there is a limit to the number of trophic levels in food chains.	• be able to interpret food webs.	• be able to produce a food web from data food provided.
• recall that intensive farming (and the burning of fossil fuels) cause changes to the environment that affect organisms.	• understand how changes in the environment are affecting plant flowering times, animal behaviour and the distribution of animals and plants.	• be able to interpret data on climate change; • explain how the effects of environmental change on plants and animals will affect food webs.

2.1.7 Selective Breeding

In addition to farming methods, another way that scientists improve the characteristics of plants and animals that are important to humans is by artificial selection or selective breeding.

You need to be able to:

- understand the principles of selective breeding.

Foundation Tier only	Both Tiers	Higher Tier only
• understand that people can select the characteristics they want to breed in plants and animals.	• describe the process of selective breeding involving the: o selection of parents with desired traits and characteristics; o cross breeding; o selection and rejection of suitable offspring over many generations; • explain how selective breeding can contribute to improved agricultural yields.	• explain that a selective breeding programme may reduce the gene pool leading to problems (reduction in variation, accumulation of harmful recessive characteristics).

2.1 LIVING ORGANISMS

2.1.8 Nature's Choosing and Changing

A similar type of selection to the one that plant and animal breeders use occurs in nature. It is called natural selection. When the environment changes, the process of natural selection leads to evolution. The theory of evolution tries to explain why at least 3 million different species of organism inhabit the planet.

You need to be able to:

- understand how the process of natural selection leads to evolution.

Foundation Tier only	Both Tiers	Higher Tier only
• know that sexual reproduction produces variation in the offspring.	• understand that some variation is useful and enables organisms to survive in changing environments.	• understand how sexual reproduction produces variation in the offspring; • understand the principles of natural selection.
	• know that scientists use similarities and differences between organisms to classify and identify them.	• interpret data on evidence for natural selection; • explain why natural selection could have led to evolution in a changing environment; • explain how recent scientific discoveries may change our understanding of natural selection (questioned validity of peppered moth data) and evolution (recent fossil discoveries by scientists changing evolutionary thinking, e.g., human evolution; evolution of flight in birds).

2.1 LIVING ORGANISMS

2.1.9 Genetics

Scientists can use their knowledge of genetics to improve the characteristics of organisms that are important to humans. You need to be able to:

- understand the mechanism of monohybrid inheritance;
- understand the principles of genetic engineering.

Foundation Tier only	Both Tiers	Higher Tier only
• state that characteristics can be passed from one generation to the next.	• explain how characteristics can be passed from one generation to the next.	• recognise dominant and recessive characteristics and explain that these depend on dominant and recessive alleles: • state that alleles are different versions of the same gene; • explain a monohybrid cross involving dominant and recessive alleles; • use and explain the terms homozygous and heterozygous;
	• recognise the process of genetic engineering as the transfer of foreign genes into the cells of animals, plants or microorganisms; • recognise some potential advantages and risks of genetic engineering and selective breeding; • recognise ethical dilemmas concerned with genetic engineering.	• describe the principles of genetic engineering: o selection of desired characteristics; o isolation of genes; o replication; o insertion; • evaluate potential advantages (improved characteristics of plants and animals) and disadvantages of genetic engineering and selective breeding (escape of foreign genes; safety of food products; ethical issues).

2.2 Humans as Living Organisms

This section looks at life processes in humans.

Workers in the medical profession need to understand how the human body functions and what to look for when things go wrong. We also need to be aware of how our lifestyle, the environment and our genetics could improve our health or contribute to disease.

This section links with section 2.1 Living organisms, in that these essential life processes are important to other living organisms.

2.2 HUMANS AS LIVING ORGANISMS

2.2.1 Moving Substances Around in the Body

Understanding of our respiratory and circulatory systems help healthcare professionals to treat conditions when these systems do not function properly. Sports' scientists study these to help to improve our lifestyles and athletic performance.

You need to be able to:

- understand the function of the respiratory system;
- understand how the circulatory system transports oxygen, food substances and waste products;
- understand the processes of aerobic and anaerobic respiration.

Foundation Tier only	Both Tiers	Higher Tier only
• name and locate the main parts of the breathing system (trachea, diaphragm, ribcage, lungs); • state the functions of the main parts of the breathing system: o lungs for gaseous exchange; o the diaphragm, ribs and intercostal muscles move to inhale and exhale; • state that exhaled air: o contains less oxygen than inhaled air; o contains more carbon dioxide than inhaled air; o contains more moisture than inhaled air; o is warmer than inhaled air.	• state the word equation for aerobic respiration: glucose + oxygen → carbon dioxide + water (+energy)	• state the symbol equation for aerobic respiration: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ (+ energy)
• state that sugar reacts with oxygen in the cells to release energy and that the process is called respiration.	• explain that during exercise the body may respire anaerobically; • state the word equation for anaerobic respiration: glucose → lactic acid + energy; • state that anaerobic respiration releases much less energy than aerobic.	• explain fatigue in terms of lactic acid build up; why lactic acid needs to be removed, and oxygen debt.

2.2 HUMANS AS LIVING ORGANISMS

2.2.1 Moving Substances Around in the Body

Understanding of our respiratory and circulatory systems help healthcare professionals to treat conditions when these systems do not function properly. Sports' scientists study these to help to improve our lifestyles and athletic performance.

You need to be able to:

- understand the function of the respiratory system;
- understand how the circulatory system transports oxygen, food substances and waste products;
- understand the processes of aerobic and anaerobic respiration.

Foundation Tier only	Both Tiers	Higher Tier only
• explain that during exercise, breathing and pulse rates increase to deliver oxygen and glucose to muscles more quickly; • state that carbon dioxide from respiration is removed from the body by the respiratory system.	• explain that high levels of CO_2 in the blood are toxic and must be removed from the body by the respiratory system; • name and locate the main parts of the lungs (bronchi, bronchioles, alveoli); • describe how the parts of the respiratory system work together to bring about gaseous exchange respiratory tree, alveoli, blood); • describe the changes in position of the ribs and diaphragm that cause inhalation and exhalation; • state the approximate percentages of gases in inhaled and exhaled air.	• explain that when increased CO_2 levels in the blood are detected the brain then brings about an increase in breathing rate; • explain how the alveoli are adapted for efficient gaseous exchange; • explain the way in which inhalation and exhalation are brought about by pressure changes.
• state that the heart pumps blood; • state that the blood moves around the body in arteries, capillaries and veins.	• describe how the parts of the circulatory system work (heart to pump blood to body and lungs; arteries transport blood away from the heart; veins transport blood to the heart; capillaries and the exchange of materials); • name and locate parts of the heart and describe their functions (left and right ventricles, left and right atria, semilunar, tricuspid and bicuspid valves).	• explain the advantage of the double circulatory system in mammals (differences in pressure in systemic and pulmonary systems); • explain the adaptations of arteries (thick, muscular, elastic), veins (presence of valves) and capillaries (one-cell thick).
• state that the blood is a fluid: o transporting food and oxygen to cells; o removing waste products; • state that blood is made up of red blood cells, white blood cells, platelets and plasma; • •state the function of plasma in transporting foods, hormones, water and waste products around the body.		• explain that haemoglobin in red blood cells reacts with oxygen in the lungs forming oxyhaemoglobin and the reverse of this reaction happens in the tissues; • state the word equation: • haemoglobin + oxygen $\rightleftharpoons$ oxyhaemoglobin.

2.2 HUMANS AS LIVING ORGANISMS

2.2.2 Co-ordination and Homeostatis

Two systems help to coordinate the activities and development of our bodies and keep our internal environment constant – the nervous system, using electrical impulses, and endocrine system, using chemicals called hormones.

You need to be able to:

- recall how the nervous system helps us to respond to our environment;
- recall that hormones help to control blood sugar and control our growth and development.

Foundation Tier only	Both Tiers	Higher Tier only
	• know that the nervous system uses nerves to communicate information rapidly around the body coordinated by the central nervous system (brain and spinal cord).	• describe the passage of the nerve impulse through a reflex arc.
• recall that the nervous system helps us to deal rapidly with situations such as keeping our body temperature constant at 37°C.	• explain how changes in the diameter of the blood vessels of the skin (vasodilation and vasoconstriction) are controlled by the nervous system and help to keep body temperature constant.	• explain that blood temperature and glucose are monitored by receptors which transmit information to the brain, bringing into place control mechanisms.
• recall that hormones bring about slower changes in our bodies, such as controlling our growth and development; • state that the pancreas produces a hormone called insulin that controls levels of blood sugar.	• state the function of insulin; • explain that people deficient in insulin suffer from diabetes, where there is fluctuation in blood sugar levels; • recall that treatment of diabetes is controlled by diet or insulin injection.	• explain how one way in which insulin reduces blood sugar levels is by converting excess blood glucose to glycogen in the liver; • explain that the dosage of insulin depends upon diet and activity; • explain the term homeostasis and how, in blood sugar regulation, it is achieved by negative feedback mechanisms.

2.2 HUMANS AS LIVING ORGANISMS

2.2.3 Diseases caused by Micro-Organisms

Most organisms are completely harmless, but a few cause disease. Scientists record and track the spread of disease across countries and around the world. In some instances, or at least not until they have carried out the necessary research, scientists are not certain what type of organism has caused a particular outbreak, or why that organism has begun to infect humans. Some of these new human diseases could severely affect the sizes of human populations over the coming years.

You need to be able to:

- recall that some diseases are caused by microorganisms;
- know how these microorganisms are spread;
- understand how our immune system helps to fight and prevent infection;
- know that antibiotics may be needed to fight some diseases caused by bacteria.

Foundation Tier only	Both Tiers	Higher Tier only
• recall that some bacteria and all viruses are examples of microorganisms that cause disease; • recall three examples of diseases caused by microorganisms.	• recall examples of infections caused by viruses in humans (measles; mumps; rubella; polio) and other animals (foot and mouth); • recall examples of infections caused by bacteria (tuberculosis; infections from *Staphylococcus aureus);* • recall examples of infection caused by fungi (athlete's foot, ringworm).	
• recall how harmful microorganisms are spread (by droplets in air; by dust; by touch; by faeces; by animals; by blood); • recall ways to protect against harmful microorganisms (personal hygiene; using disinfectants, antiseptics, heat and radiation; protective clothing and isolation).	• explain how harmful microorganisms are spread (by droplets in air; by dust; by touch; by faeces; by insects; by blood); • explain how, for each method of transmission, the spread of microorganisms is reduced.	• interpret data that scientists use to track the outbreak and spread of a disease.
• recall that when a person gets a disease, the body produces chemicals called antibodies that attack the microorganisms causing the disease; • recall that we can cause our bodies to produce antibodies to fight off diseases by immunisation.	• explain that our skin is a barrier to infection, and explain that blood clotting bridges that barrier if the skin becomes broken; • explain that when a person gets a disease the body produces chemicals called antibodies that attack the microorganisms causing the disease.	

2.2 HUMANS AS LIVING ORGANISMS

2.2.3 Diseases caused by micro-organisms

Most organisms are completely harmless, but a few cause disease. Scientists record and track the spread of disease across countries and around the world. In some instances, or at least not until they have carried out the necessary research, scientists are not certain what type of organism has caused a particular outbreak, or why that organism has begun to infect humans. Some of these new human diseases could severely affect the sizes of human populations over the coming years.

You need to be able to:

- recall that some diseases are caused by microorganisms;
- know how these microorganisms are spread;
- understand how our immune system helps to fight and prevent infection;
- know that antibiotics may be needed to fight some diseases caused by bacteria.

Foundation Tier only	Both Tiers	Higher Tier only
• recall that we are immunised against: o MMR (measles, mumps and rubella); o TB (tuberculosis); o polio; • interpret simple data about the effectiveness of vaccines in fighting disease.	• explain how putting small quantities of dead or weakened microorganisms into the blood causes the production of antibodies to specific diseases; • explain why girls are especially encouraged to be immunised against rubella.	• evaluate data about the effectiveness of vaccines; • evaluate data on the use of the MMR vaccine, and discuss how opinions based on science can change over a period of time.
• recall that in some instances the immune system cannot fight disease and chemicals called antibiotics (against bacteria), antivirals (against viruses) and antifungals (against fungi) are required; • recall that antibiotics are obtained from microorganisms; • recall that the first antibiotic was discovered by Alexander Fleming in 1928.	• explain that antibiotics are used to kill some bacterial micro-organisms but do not kill viruses; • describe how new antibiotics are tested and trialled before being used on patients.	• explain why a course of antibiotics is sometimes useful when a patient has suffered from a viral disease to treat secondary bacterial infections; • interpret data to assess the suitability of an antibiotic.

2.2 HUMANS AS LIVING ORGANISMS

2.2.4 Other Causes of Diseases

You need to be able to:

- recognise that health can be affected by the use and misuse of chemical substances;
- recognise that some diseases have genetic causes.

Foundation Tier only	Both Tiers	Higher Tier only
• state how tobacco, solvents, alcohol and recreational drugs can affect physical and mental health; • know about the effects of passive smoking.	• interpret data on the misuse of substances; • recognise that some misused drugs can also be the source of medicinal drugs (opiates); • recognise that scientific opinion has changed, and that the recreational drug cannabis has been used to reduce suffering in patients with multiple sclerosis.	
	• recognise that some diseases (cystic fibrosis; Huntington's chorea) have genetic causes.	• use a knowledge of genetics to explain the inheritance of single gene disorders caused by recessive alleles (cystic fibrosis) and dominant alleles (Huntington's chorea); • use a knowledge of genetics to explain why some people are carriers of single gene disorders.

2.3 Obtaining Useful Chemicals

Some scientists work to obtain useful chemicals from natural raw materials. It is important to understand the differences between elements, mixtures and compounds. The vast majority of chemical substances are found in the earth as compounds. Some substances are used as they are, straight from the ground; some are separated from their natural mixture before use; and some are used as the starting material to make other useful substances. The extraction and processing of materials is a bulk industry. Scientists are involved at every stage to make the industry as efficient as possible, and to minimise the environmental impact of the processes.

The chemical industry is a huge industry and produces the vast range of materials we use in our everyday lives. Scientists are employed at every stage of production, from developing new materials to ensuring that processes do not cause unnecessary harm to the environment. Scientists use patterns of chemical behaviour to make decisions in their work (for example, metal reactivity and rates of reaction). Two important aspects of manufacturing are to produce maximum yield and to control the rates of reaction in chemical processes.

This section links with Section 2.4 Chemical and Material Behaviour, which develops ideas about bonding Ideas about the effects of industry on the environment are further developed in Sections 2.5, The Importance of Energy and 2.6, the Earth and universe.

In addition to the work you carry out in this section, in Unit 1: Developing Scientific Skills, you will learn about the chemical analyses that scientists carry out and produce three chemical products in Unit 3: Science at Work.

2.3 OBTAINING USEFUL CHEMICALS

2.3.1 Useful Chemicals – The Building Blocks

It is important that chemists are aware of the building blocks from which all materials are made. This knowledge forms the basis of the formation of mixtures and compounds in thousands of commercial products used worldwide.

You need to be able to:

- classify chemical substances as elements, compounds and mixtures;
- know the symbols for key elements;
- understand the structure of the atom;
- name some simple compounds and state their formulae;
- recognise inorganic and organic substances;
- write word and symbol equations for chemical reactions.

Foundation Tier only	Both Tiers	Higher Tier only
• define an element, compound and mixture; • match up symbols and names of elements (see Appendix D).	• classify materials as elements, compounds or mixtures using information provided; • recall the chemical symbols of the elements listed in Appendix D of the specification.	
• state that all matter is made up of small particles called atoms.	• recall that atoms consist of a central nucleus, composed of protons and neutrons, surrounded by orbiting electrons; • recall that all of the atoms that make up a chemical element have the same number of protons and electrons in their atoms.	
• match up formulae and names of compounds (see Appendix D of the specification); • recognise reactants and products in a symbol equation.	• name the compounds listed in Appendix D of the specification given their formulae; • write word and symbol equations to show how atoms are rearranged in the chemical reactions in this specification.	• recall and use the formulae of the compounds listed in Appendix D of the specification to write balanced symbol equations.

2.3 OBTAINING USEFUL CHEMICALS

2.3.1 Useful Chemicals – The Building Blocks

It is important that chemists are aware of the building blocks from which all materials are made. This knowledge forms the basis of the formation of mixtures and compounds in thousands of commercial products used worldwide.

You need to be able to:

- classify chemical substances as elements, compounds and mixtures;
- know the symbols for key elements;
- understand the structure of the atom;
- name some simple compounds and state their formulae;
- recognise inorganic and organic substances;
- write word and symbol equations for chemical reactions.

Foundation Tier only	Both Tiers	Higher Tier only
• state that scientists sort out chemicals into two groups, those that contain carbon and those that do not; • state that living things all contain the element carbon; • state that non-living things do not usually contain the element carbon; • recall the names of some chemicals that do not contain the element carbon (for example metals, ceramics and fertilizers); • recognise inorganic and organic substances;	• use the word organic to describe most compounds containing the element carbon; • use the word inorganic to describe most compounds that do not usually contain the element carbon; • explain the origin of the words organic and inorganic; • use chemical formulae to recognise a substance as organic or inorganic;	
• recall that there are many useful substances that contain carbon atoms (for example petroleum products and polymers).	• explain why fossil fuels are a source of organic substances; • state that organic chemicals are very important in our lives and most are derived from crude oil.	

2.3 OBTAINING USEFUL CHEMICALS

2.3.2 Useful Chemicals – Using Raw Materials

Useful chemicals must be obtained from natural raw materials or manufactured.

You need to be able to:

- recognise useful substances that come straight from the ground;
- know that some substances have to be separated before they are useful;
- discuss issues relating to the competing demand for crude oil as a resource;
- know about the extraction of metals from their ores;
- know how scientists work to minimise effects of their activities on the environment.

Foundation Tier only	Both Tiers	Higher Tier only
• state that gold is a metal and sulfur is a non-metal which can be found in the ground uncombined; • state one use for gold and one use for sulfur; • state that limestone and marble are examples of a chemical compound called calcium carbonate; • state one use for limestone and one use for marble;	• explain why some substances, such as gold, sulfur, limestone and marble can be used straight from the ground;	
• state that rock salt and crude oil are mixtures obtained form the Earth's crust; • state how rock salt is used in its unpurified form and purified;	• describe how pure salt (sodium chloride) can be obtained from rock salt in industry and in the laboratory;	• describe how scientists work to minimise the effects of mining on the environment (monitoring and conserving local ecology, redevelopment of old mines, treatment of dust and contaminated water);
• state that crude oil can be separated into more useful substances by a process called fractional distillation; • state that bitumen, paraffin wax, kerosene, petrol, butane and propane are made from crude oil; • recall that most consumer products are made from chemicals in crude oil (for example plastics, packaging, textiles, dyes, paints, medicines).	• describe industrial fractional distillation; • interpret data about the competing use of oil as a chemical feedstock and a fuel.	• relate the difference in boiling points of liquids to the differing intermolecular forces between different sized molecules; • explain why it is environmentally and economically important to match supply and demand in the processing of oil fractions.

2.3 OBTAINING USEFUL CHEMICALS

2.3.2 Useful Chemicals – Using Raw Materials

Useful chemicals must be obtained from natural raw materials or manufactured.

You need to be able to:

- recognise useful substances that come straight from the ground;
- know that some substances have to be separated before they are useful;
- discuss issues relating to the competing demand for crude oil as a resource;
- know about the extraction of metals from their ores;
- know how scientists work to minimise effects of their activities on the environment.

Foundation Tier only	Both Tiers	Higher Tier only
• state that most chemical substances are found in the Earth as compounds and are in mixtures that require separation; • state that an ore is a mixture of a mineral and surrounding rock; • state that iron can be extracted from iron ore by heating with carbon;	• state that more reactive metals (for example lead and iron) occur naturally as compounds and need to be extracted by chemical methods; • be able to write a word equation for the reduction of haematite (iron (III) oxide);	• interpret and construct, given suitable information, symbol equations to describe the reduction of iron from iron oxide and lead from lead oxide;
• outline the effects of large scale extraction on the local environment and community (e.g. landscape, transport, waste disposal and jobs).	• state examples of how scientists minimise the effect of metal extraction (for example, gas scrubbing, use of waste carbon monoxide for heating fuel, treatment of contaminated water).	• interpret data about the environmental effects of waste products from metal extraction from ores (for example disposal of solid waste, the hazardous nature of waste gases such as carbon monoxide and sulfur dioxide from sulfide ores).

2.3 OBTAINING USEFUL CHEMICALS

2.3.3 Chemical Manufacture

The chemical industry is responsible for the manufacture of hundreds of products that affect our daily lives. It is important that the processes are efficiently run and environmentally friendly. Some raw materials are extracted and used to make bulk or fine chemicals. The industry uses both organic and inorganic chemicals. Organic chemicals usually come from crude oil.

You need to be able to:

- identify examples and bulk and fine chemicals;
- write chemical equations for the production of ammonia, sulfuric acid and poly(ethene);
- interpret data on manufacturing processes;
- describe the factors that explain how quickly a reaction occurs.

Foundation Tier only	Both Tiers	Higher Tier only
• recognise that we use things such as fertilisers on a very large scale and that this requires large scale production in the chemical industry;	• state that some substances are produced on a large scale in the chemical industry and are called bulk chemicals; • recall that ammonia, sulfuric acid and poly(ethene) are examples of bulk chemicals;	
• recognise that we use things such as medicines on a smaller scale and that this requires small specialist production;	• state that some substances are produced on a very small scale in the chemical industry and are called fine or speciality chemicals; • recall that medicines, dyes and pigments are examples of fine or speciality chemicals;	
• state some examples of how scientists work the chemical industry (for example in research and development of new products, designing or refining manufacturing processes, quality control, environmental science); • know some examples of factors that speed up reactions (for example temperature, surface area, concentration, use of a catalyst).	• interpret data about manufacturing processes relating to economical running costs and the environment (for example, use of fuel and disposal of waste); • interpret data from tables and graphs relating to rate of reaction (for example qualitative link between a steeper gradient and higher rate); • explain why controlling rates is important to large industrial processes (for example, cost of fuel for high temperatures balanced with speed of manufacture of product).	• given suitable information, interpret and construct symbol equations to describe named reactions; • use collision theory to explain the effect of an increase in concentration on the rate of reaction; • use given information to discuss the reasons for choosing conditions for a process (for example, ammonia and sulfuric acid); • explain that the use of a catalyst lowers energy demand for an industrial process.

2.4 Chemical and Material Behaviour

All of the products that we use in our everyday lives, for example, for buildings, vehicles, clothing, household appliances, trainers, mobile phones and sports products are constructed from materials. Four important types of manufactured materials are metals, polymers, ceramics and composites. Scientists are involved at every stage of making and testing these materials, and are also responsible for matching the properties of manufactured materials to their composition, structure and uses. Most modern products contain a combination of many chemical substances, each contributing an advantage to the finished product. These substances can be either mixed (for example toothpaste, shaving foam) or held together as separate materials within a composite (for example laminate flooring).

Scientists working with materials need to know about how the atoms are held together. Chemical compounds are held together by bonds, either ionic or covalent. The bonding in a compound dictates its physical and chemical properties. This section links with section 2.3 Making Useful Chemicals, which covers symbols and formulae, atomic structure, metal extraction and the chemical industry.

In addition to the work you carry out in this section, in Unit 1: Developing Scientific Skills, you will learn how scientists carry out tests to determine the properties of materials.

2.4 CHEMICAL AND MATERIAL BEHAVIOUR

2.4.1 Mixtures

Many useful products are mixtures of solids, liquids or gases. The labels on commercial products give a list of the substances present, their use and instructions on how to use. Most large companies have their own quality control labs to monitor the quality and composition of their products.

You need to be able to:

- classify types of material and describe their uses.

Foundation Tier only	Both Tiers	Higher Tier only
• state that many materials we use consist of one substance finely mixed with another; • recognise that the substances in the mixture may be solids, liquids or gases; • identify examples of mixtures with one substance finely mixed with another, for example: o solutions and suspensions as examples of a solid in a liquid; o gel as a liquid in a solid; o emulsions as one liquid in another; o foams as a gas in a liquid; o aerosols as a liquid in a gas; • identify the states of matter that make up examples of these mixtures; • recall a use for one example of each type of mixture.	• describe the difference between a solution and suspension; • state that a colloid consists of one substance (or mixture of substances) finely dispersed in another substance (or mixture of substances); • use the terms disperse phase and continuous phase to describe colloids; • describe the disperse phase and the continuous phase of a variety of colloids (a gel as an example of a liquid dispersed in a solid; a sol as a solid dispersed in a liquid or solid; an emulsion as one liquid dispersed in another; a foam as a gas dispersed in a liquid or solid; an aerosol as a liquid dispersed in a gas); • explain how the properties of each example makes it fit for its use.	

2.4 CHEMICAL AND MATERIAL BEHAVIOUR

2.4.2 Materials

Once scientists understand the links between properties and structure they can design materials with the properties we want, for example by mixing materials to make composites or by redesigning materials at the molecular level.

You need to be able to:

- understand ionic, covalent and metallic bonding;
- classify materials as metals, polymers, ceramics and composites;
- describe the uses of these types of materials;
- investigate properties of different materials;
- relate the properties of materials to their structure and uses;
- select material for a particular product.

Foundation Tier only	Both Tiers	Higher Tier only
• recall four important types of materials (metals; polymers; ceramics; composites).	• recall that atoms in compounds are held together by bonds (ionic and covalent); • recall the characteristic properties of ionic and compounds; • explain that any object that we build has a purpose and the materials used to make it must have properties to suit that purpose;	• explain that atoms share or transfer electrons in order to get a complete outer shell; • recognise that when atoms share electrons, the bond formed is called covalent; • describe the formation of hydrogen chloride and water by the use of the 'dot and cross' model; • recognise that when atoms transfer electrons the bond formed is called ionic; • describe the formation of sodium chloride and magnesium oxide by the use of the 'dot and cross' model.
• be able to relate simple metal properties to their uses (for example, hardness, density, electrical and thermal conductivity, melting point, corrosion resistance).	• recall that metals are strong, tough, and are good conductors of heat and electricity; • recall uses for iron, copper and aluminium to illustrate the properties of these metals; • be able to interpret data about metal properties from various sources (for example tables, graphs, websites); • state advantages and disadvantages of metal recycling.	• explain the electrical conductivity, malleability, hardness and high melting point of metals in terms of metallic bonding (ions held strongly in mobile electrons); • be able to use a particle model of metallic structure to explain why atoms of different sizes in alloys affect the strength, hardness and malleability.

2.4 CHEMICAL AND MATERIAL BEHAVIOUR

2.4.2 Materials

Once scientists understand the links between properties and structure they can design materials with the properties we want, for example by mixing materials to make composites or by redesigning materials at the molecular level.

You need to be able to:

- understand ionic, covalent and metallic bonding;
- classify materials as metals, polymers, ceramics and composites;
- describe the uses of these types of materials;
- investigate properties of different materials;
- relate the properties of materials to their structure and uses;
- select material for a particular product.

Foundation Tier only	Both Tiers	Higher Tier only
• recall the uses of some polymers (nylon and poly(ethene); • state that some polymers melt when heated (for example nylon, poly(ethene)) and some do not (for example melamine); • be able to link the use of a polymer to its simple properties, given information.	• recall the properties of polymers (for example nylon and poly(ethene)) and explain why they are useful.	• explain the difference between the terms thermosetting and thermoplastic; • explain that polymers consist of long chains of atoms with only weak forces between the chains to explain why they melt easily, are neither stiff nor strong, but are tough; • recall that some polymers (for example Bakelite and melamine) have cross links between the chains of atoms and this changes the properties of the polymer (stiffness and heat resistance); • describe the use of esters as plasticisers in changing the properties of PVC to become flexible and useful for cling film.
• recall that glass, pottery and cement are examples of ceramic materials; • recall that a composite material is a mixture of two other materials and combines the properties of the materials from which it is made; • recall that GRP and steel reinforced concrete are examples of composite material.	• recall the properties of ceramics (for example glass, pottery and cement) and explain why they are useful; • recall uses for glass, pottery and cement to illustrate the properties of these ceramics.	• relate the properties of ceramic materials to their structure; • explain the difference in properties of fired and unfired clay in terms of the change in structure when clay is fired (formation of cross links); • explain that the particles in ceramics are joined in giant structures where there are strong forces between all of the particles throughout the structure; • explain why composites are better than metals, ceramics or polymers for many uses (for example GRP and steel reinforced concrete).

2.4 CHEMICAL AND MATERIAL BEHAVIOUR

2.4.2 Materials

Once scientists understand the links between properties and structure they can design materials with the properties we want, for example by mixing materials to make composites or by redesigning materials at the molecular level.

You need to be able to:

- understand ionic, covalent and metallic bonding;
- classify materials as metals, polymers, ceramics and composites;
- describe the uses of these types of materials;
- investigate properties of different materials;
- relate the properties of materials to their structure and uses;
- select material for a particular product.

Foundation Tier only	Both Tiers	Higher Tier only
• know examples of the work of scientists in developing new materials (for example development, testing, specification matching, development of necessary component material such as glues, design of manufacturing process, safety, environmental considerations); • link uses to properties when all of the information is given; • interpret simple data presented in a variety of forms (tables, graphs, databases, prose) to find the physical properties of materials.	• recall the components in GRP and steel reinforced concrete as examples of composite material; • recall the properties of composites (for example GRP and steel reinforced concrete) and explain why they are useful; • interpret data presented in a variety of forms (tables, graphs, databases, prose) to find the physical properties of materials; • select materials for a product, given a specification, and explain the reasons for the choice of each material.	• recall that some polymers (for example Bakelite and melamine) have cross links between the chains of atoms and this changes the properties of the polymer (stiffness and heat resistance); • describe the use of esters as plasticisers in changing the properties.

Section 2.5 Importance of Energy, Electricity and Radiation

We need a source of energy to change things or make things happen. Fossil fuels are examples of primary energy resources. They are valuable because they are concentrated sources of energy, which is released by burning them in oxygen. However, there is only a limited amount of fossil fuel in the Earth's crust and they are also a valuable source of chemicals that we use to make many necessary consumer products such as paint, drugs and plastics. Instead of wasting these resources by burning them, we could obtain our energy from alternative sources such as use nuclear fuels or renewable energy resources such as solar, wind and wave power.

In order to conserve these resources it is important that scientists make machines as efficient as possible, obtaining the maximum amount of work from as little amount of energy as possible.

This section links with section 2.4 Chemical and Material Behaviour, which develops ideas about types of reaction, and section 2.6 The Earth and the Universe.

2.5 ENERGY RESOURCES

2.5.1 Energy Resources – fuels

You need to be able to:

- know that fossil fuels are useful energy resources and the problems of burning fossil fuels;
- know about the use of nuclear fuel as a source of energy and the associated problems;
- know about the use of renewable energy resources and the associated problems.

Foundation Tier only	Both Tiers	Higher Tier only
• recall that fossil fuels (natural gas, crude oil and coal) were formed from the remains of once living things; • recall that fossil fuels are a source of energy; • recall that many consumer products are made from chemicals from crude oil.	• recall that the energy within fossil fuels can be released by burning them in oxygen; • list the factors that need to be considered in the use of fossil fuels (energy value, short and long term availability, storage, cost, pollution, ease of use).	• evaluate the use of different fossil fuels given data.
• recall that fossil fuels are non-renewable.	• explain the terms non-renewable and renewable energy source.	• evaluate the use of renewable energy; • recognise that some areas in the use of renewable energy are uncertain, e.g. projected costs; recycling and toxicity of solar cells.
• recall that some elements are radioactive and give out energy and that these are called nuclear fuel; • recall that using nuclear fuel saves the use of fossil fuels but may cause other pollution problems.	• state that radioactive materials emit radiation and that obtaining energy from nuclear fuels produces radioactive waste.	• evaluate the use of nuclear fuels and disposal of waste in terms of scientific, environmental and ethical issues.
• recall that the wind, sun, water and biomass can be used as renewable energy sources; • state an advantage and a disadvantage of using wind, sun, water and biomass as energy sources.	• recall examples of renewable energy sources (e.g. wind farms; solar cells; hydroelectricity; wave; tidal; biomass; biofuel); • describe the advantages and disadvantages of renewable energy sources.	• understand that biomass energy and biofuels are CO_2 neutral; • know that scientists are looking for other solutions to alleviate energy shortages e.g. fuel cells, nuclear fusion.

2.5 ENERGY RESOURCES

2.5.2 Energy Resources – Energy Transfers

Electricity is a means of transferring energy and is generated from a primary source. In most power stations this is done by using a fuel to boil water and then using the steam to turn a turbine which rotates a generator to produce electricity.

You need to be able to:

- recall that energy can be transferred from one form to another;
- know how electricity is generated and distributed and why it is useful;
- understand the meaning of efficiency when applied to simple energy transfers in electrical appliances;
- know how to calculate the cost of running electrical appliances.

Foundation Tier only	Both Tiers	Higher Tier only
• recall that energy can be in many forms (heat, electricity, sound, light or movement) and can be transferred from one form to another;	• explain that in any process of energy transfer energy is conserved.	
• explain why electricity is an important way of supplying energy to the home; • recognise that there is a significant energy waste in the production of electricity at a conventional power station.	• explain the advantages and disadvantages of electricity compared with other methods of supplying energy to the home; • describe how domestic electricity is generated at a power station; • describe how the National Grid of powerlines connects power stations to consumers.	
• evaluate the suitability of different energy resources for a particular job in the home or workplace (natural gas, bottled gas, mains electricity, batteries, solid fuel, petrol/diesel, fuel oil); • state that owners of homes and workplaces seek to reduce wastage of energy to reduce cost; • recall that efficient energy sources transfer most of the energy from one form to another with little loss to the surroundings; • recall that inefficient energy sources transfer little of the energy from one form to another with much lost to the surroundings; • interpret energy changes shown as simple Sankey diagrams.	• use the term *energy efficiency*; • state and use the relationship for energy or power: $\% \text{ efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}} \times 100\%$ • construct and interpret energy changes shown as Sankey diagrams; • recall and use the formula: power = voltage x current	

2.5 ENERGY RESOURCES

2.5.2 Energy Resources – Energy Transfers

Electricity is a means of transferring energy and is generated from a primary source. In most power stations this is done by using a fuel to boil water and then using the steam to turn a turbine which rotates a generator to produce electricity.

You need to be able to:

- recall that energy can be transferred from one form to another;
- know how electricity is generated and distributed and why it is useful;
- understand the meaning of efficiency when applied to simple energy transfers in electrical appliances;
- know how to calculate the cost of running electrical appliances.

Foundation Tier only	Both Tiers	Higher Tier only
• use simple data to show that a low energy lamp is more efficient than a filament lamp; • recognise that some electrical appliances are more expensive to use than others; • state the relative expense of different appliances given power ratings; • take readings from a domestic electricity meter.	• use a comparison of low energy lamps and filament lamps to illustrate the advantages to the user and society of devices with high efficiency; • recognise and use given information on electrical appliances; • carry out simple calculations using the formula (given): power = energy / time to calculate power in watts (W); • calculate the number of kWh units given the power in kW and the time in hours.	• evaluate data on different types of lighting systems to compare their efficiencies.

2.5 ENERGY RESOURCES

2.5.3 Energy Resources – Conserving Energy

You need to know:

- how heat losses may be minimised by insulation and heat exchange systems.

Foundation Tier only	Both Tiers	Higher Tier only
• recognise the term insulation;	• describe how energy is transferred by conduction, convection, radiation; • explain the term insulation;	• use a particle model to explain how energy spreads out;
• recognise examples of energy saving methods in the home or workplace; • recall methods of insulation used: loft, cavity wall, double glazing; lagging;	• describe methods of insulation used in the home or work place;	• explain energy saving strategies in the context of the home or workplace;
• recognise that when energy is wasted it becomes spread out and is hard to reuse; • state that a heat exchanger enables waste energy to be captured and recycled; • state that a car radiator and a refrigerator are examples of heat exchangers.	• calculate costs and interpret data to do with energy saving in the home or workplace (including pay-back time); • use the term heat exchanger as a device that captures and recycles energy; • explain that a car radiator and a refrigerator are examples of heat exchangers.	

2.5 ENERGY RESOURCES

2.5.4 Working waves

Modern communication systems are dependent on electromagnetic waves. Waves have always been important to communication – we couldn't see or hear without them and medical workers use waves to diagnose and treat problems with the human body.

You need to be able to:

- know that electromagnetic radiation transfers energy from place to place;
- identify the regions of the electromagnetic spectrum;
- understand the relationship between wavelength and frequency and type of electromagnetic radiation;
- describe how waves are used in communication devices.

Foundation Tier only	Both Tiers	Higher Tier only
• know that electromagnetic radiation travels as waves; • know a definition for frequency and wavelength; • identify the regions of the electromagnetic spectrum;	• describe, in terms of wavelength and frequency the differences between the regions of the electromagnetic spectrum;	• recall and use the equation: $v = f\lambda$ where: v is velocity f is frequency λ is wavelength
• be able to state one use in communication systems: o radio waves –radio and TV; o microwaves –mobile phones; o infra-red – remote controls and thermal imaging; o visible – fibre optics.	• be able to describe the importance of carrying information over short and long distances by: o radio waves – radio and TV; o microwaves – mobile phones; o infrared – remote controls and thermal imaging; o visible – fibre optics.	• understand how infra-red can be monitored using special detectors and is used in forensic science, night sights and burglar alarms; • lasers emit signals that can carry information through optical fibres and how leakage of light is prevented by total internal reflection.

Section 2.6 Earth and Universe

It is intended that questions based on this section will be mainly data interpretation.

We depend on the earth and its atmosphere staying largely unchanged to support our life and the demands of our industrial society. However, the earth and its atmosphere continuously change over time. Most of these changes happen very slowly. Our atmosphere has taken thousands of millions of years to form, and changes to the surface of the earth are usually measured in millions of years and are too slow to see. Some changes happen more quickly, either naturally (such as earthquakes) or as a result of human activity (such as current concerns over climate change). Scientists work to understand our atmosphere and the structure of the earth by analysing the composition of samples over periods of time. This can lead to making reliable predictions about what happens in the future.

The Earth is a small insignificant part of a universe that is so vast it is impossible to comprehend it. However it is important to understand the place of the Earth in the universe, and the relationships that exist between the planets, stars and galaxies that constitute it. Like the Earth the universe is changing. Scientists work to understand these structures and changes and to understand how the universe was created and what its ultimate fate will be.

This section links to work relating to the chemical industry and the environment in section 2.3, 'Obtaining Useful Chemicals' and 2.4 ' Material and Chemical Change'. It also links to ideas about renewable and non-renewable energy resources in section 2.5, 'The Importance of Energy'.

2.6 PLANET EARTH

2.6.1 Planet Earth – the atmosphere

The scientist's role is key to understanding the effect of human activities on the earth's environment and the effects these might have.

You need to be able to:

- know about the composition of the earth's atmosphere;
- explain the effects of human activities on the composition of the Earth's atmosphere;
- describe how scientists monitor environmental change;
- interpret information and data relating to environmental change.

Foundation Tier only	Both Tiers	Higher Tier only
• state the main gases in the atmosphere (approximate percentages of nitrogen and oxygen, carbon dioxide); • state how the Earth's atmosphere is changing as a result of human activities.	• explain how the composition of the atmosphere is essential in maintaining conditions for life (the natural greenhouse effect, oxygen for aerobic respiration).	• outline the origin of the Earth's atmosphere.
• state why it is important to monitor these changes (climate change and health issues).	• know how science can be used to monitor environmental change resulting from human activities: o emissions from motor vehicles and power stations; o CO_2 levels (in atmosphere, historical levels in ice cores); o temperature and precipitation records;	
	• interpret data relating to changes in composition of the atmosphere and climate change.	• explain how the increase in greenhouse gases has led to the enhanced greenhouse effect.

2.6 PLANET EARTH

2.6.2 Planet Earth – the surface

Geologists study the nature of the earth's surface. Their knowledge and understanding has enabled teams of scientists to put forward theories as to how the world's continents and natural features were formed and to predict when and where natural disasters may occur.

You need to be able to:

- describe the changes in the outer layer of the earth resulting from the movement of tectonic plates and their effects and how these are monitored by scientists.

Foundation Tier only	Both Tiers	Higher Tier only
• state that some changes to the Earth's surface occur slowly over time and have led to the formation of the continents.	• know that the surface of the earth is composed of tectonic plates.	• understand the forces that lead to plate movement (convection currents, gravity, thermal plumes).
• state that some changes to the Earth's surface happen very quickly and can lead to natural disasters (volcanoes, earthquakes, tsunamis).	• know about some of the changes that take place as a result of plate movement (continental drift, mountain formation, volcanoes, earthquakes, tsunamis).	• explain evidence from the fossil record for continental drift.
	• recall how data on earth movements are collected and used.	• recall reasons why Wegener's theory for continental drift (1912-15) was not accepted until the 1960s.

2.6 PLANET EARTH

2.6.3 Exploring the Universe

The earth is one small planet in the solar system. Astronomers work together to explore the solar system, stars and the galaxies in the universe.

You need to know:

- that evidence suggests that the universe began with the ‘big bang’ and it is currently expanding;
- about the solar system and its relationship to the rest of the universe.

Foundation Tier only	Both Tiers	Higher Tier only
• know that the universe was created from the ‘big bang’.	• understand the relationship between galaxies, stars and the solar system.	• understand the differences between stars, planets and satellites in terms of radiation and reflection of light.
• know that the universe is still expanding.	• understand that a light-year is a unit of distance and have some appreciation of how large the universe must be.	
	• state that astronomers use different types of telescopes to gather information on the moon, planets and stars.	• describe the main differences between Pluto and the other planets and relate this to how scientific opinion has changed.
		• evaluate the scientific and economic issues of space travel.

UNIT 3: SCIENCE AT WORK

About this Unit

In this unit you will find out how science may be used to the great benefit of industry and society. You will look at how scientific knowledge and understanding, along with underpinning practical skills are applied, both in the school and college laboratory and in the workplace. You will learn about:

- science in the workplace;
- making useful products;
- instruments and machines;
- monitoring living organisms.

Scientists often make use of information/data already obtained by other scientists. In this unit, you will be carrying out tasks and investigations which may require you to use information/data from other sources.

You need to be able to:

- identify when you need more information/data;
- identify likely sources of this information/data, including CD-ROMs and the internet;
- select the information/data you need from these sources.

The unit also links with units from other GCSEs in vocational subjects, such as *Engineering* and *Health and Social Care* and with some NVQs, such as *Laboratory and Associated Technical Activities and Laboratory Technicians: Working in Education*. Level 2 NVQs are required as part of a Foundation Modern Apprenticeship.

Portfolio work in parts of this unit can be extended to fulfil the requirements of Unit1: Science at Work, of the OCR Advanced Subsidiary GCE in Applied Science (H175)

*You should be **selective** and include in your portfolio only work from this unit that **meets the evidence requirements.***

This unit is assessed solely through portfolio assessment.

What you need to learn

Science in the Workplace

Applied science is the science and skills used by people in a wide variety of jobs. Those with a major job role in science may classify things, obtain or make things and monitor and control changes. The more scientists know about the materials and equipment they work with, the more effective they can be. Scientists tackle problems, sometimes straightforward, often complex. This requires employing scientific skills and knowledge, coupled with imagination and curiosity. However, there are many people, who use science in their work who we do not think of as scientists. For some, it is a significant part of their work (e.g. nurses, engineers), for others, it plays a smaller part (e.g. photographers, chefs, gardeners).

You need to:

- find out what careers are available in science and science-related areas;
- identify organisations that use science.

For each organisation that you research, you need to:

- find out where the organisation is located
- describe the work carried out by the organisation;
- give scientific, economic, social and environmental reasons for the location of this organisation;
- describe the type of scientific work carried out by employees in the organisation;
- investigate the job titles, qualifications and skills of these employees.

Candidates working towards higher levels should study two organisations at level 2 and two at level 3. The range should be chosen to cover a diversity of scientific areas.

Making Useful Products

Naturally-occurring materials such as metals, rocks and minerals can be made into more useful products by physical or chemical change. Industries have to make profits and need to maximise the amount of product produced from the starting materials. For this reason, scientists often have to work quantitatively, that is, to accurately measure the amounts of chemical products and calculate the yield. Useful products are made in industry by using many different types of chemical reaction.

In addition to the starting materials required and amount of product made, Scientists also consider carefully the energy input needed. They also consider methods used to disperse of waste product safety.

You need to:

- prepare pure, dry products using two different types of chemical reaction;
- explain the underlying chemistry involved in each type of reaction;
- identify an industrial application of each reaction;
- explain the industrial importance of each type of reaction;
- for one of the reactions carried out in a industrial scale, research raw materials used, energy inputs and treatment and disposal of waste.

For each preparation you carry out, you need to:

- carry out a risk assessment;
- measure the actual yield;
- write an equation to describe the reaction,
- calculate the theoretical yield and the percentage yield;
- evaluate fully the procedure used to synthesis the product.

Electronic and optical devices

Scientists produce many devices to detect and measure environmental changes, to observe phenomena and to communicate information. There are many electronic and optical devices that are used in our homes, at work or during our leisure time. All must be designed and built to do their job.

You need to:

- describe the use of electronic devices for:
    - sensing, monitoring and controlling electro-mechanical devices or machines;
    - controlling movement;
    - monitoring and controlling physical conditions;
- describe the use of optical devices:
    - refracting light to produce images in cameras, microscopes, spectacles and telescopes;
    - reflecting light using mirrors and prisms, and devices that use mirrors and prisms, including cameras, telescopes, solar heating devices
    - the use of laser light in optical communication, optical storage media and microscopy

- describe the functions of the following components:
    - in an electronic device:

power source;

processor;

input components;

output components;

- or in an optical device:

light source (natural and artificial light sources; lasers)

lenses and/or mirrors

- assemble and assess the effectiveness of one electronic or optical device by:

selecting the components you need;

safely assembling them to build the device;

testing the assembled device under conditions of normal use;

evaluating the performance of the device and commenting on its fitness for purpose.

Mechanical Devices

Simple mechanical devices such as pulleys, levers and gears make our lives easier. They all use a force applied at one point to overcome a force at another.

You need to:

- identify a range of components in mechanical devices used in the workplace;
- explain how these components work;
- assemble and assess the effectiveness of one mechanical device:
    - selecting the components you need;
    - safely assembling them to build the device;
    - measure the applied force and the force produced by the machine;
    - calculate the amount the device multiplies force;
    - calculate the work done by the device;
    - calculate the efficiency of the device;
    - evaluating the performance of the device and commenting on its fitness for purpose.

Higher level candidates will be required to investigate the performance of a specified device, making measurements and carrying out calculations to evaluate its performance.

Monitoring Living Organisms

Organisms are adapted to survive within a range of conditions. When scientists grow organisms to obtain products from them, they must provide them with the conditions which will maximise the amount of product obtained. This involves monitoring the activities/responses of the organism and the conditions in which it is kept.

Humans also operate best within a range of conditions. Athletes can improve their physical and mental performance by training and maintaining their health by monitoring their own activities.

You need to investigate the growth and/or development and/or responses of an organism under controlled conditions.

It is important that you show appropriate care and consideration to living organisms during this activity and follow procedures which are ethical.

You need to:

- select an organism for a particular purpose which you can monitor;
- produce a plan for your investigation that includes information about:
  - the type of organism;
  - the purpose of your monitoring activity;
  - how you have considered the welfare of the organism, where appropriate, and taken into account any ethical issues;
  - the conditions you will be providing and controlling;
  - how you intend to monitor the organism's growth/development/responses;
  - a monitoring schedule for the duration of your investigation;
- carry out the investigation;
- record relevant data;
- analyse your results
- explain what the results show (using scientific knowledge and understanding);
- evaluate your investigation.

Assessment Evidence for Unit 3: Science at Work

You need to produce a laboratory notebook or file in which you have recorded a report on:

a how science is used in the workplace [11 marks];

b the production of pure, dry samples from two types of chemical reaction [13 marks];

c the assembly and assessment of the effectiveness of one electronic or optical device [7 marks];

d mechanical devices [6 marks];

e monitoring the growth/development/response of an organism [13 marks].

A typical candidate at grades GG, FF, EE will:	A typical candidate at grades DE to BC will:	A typical candidate at grades BB, AA, A*A* will:	Mark	Max
a1	a2	a3		
• identify careers that are available in science and science-related industries;				
• in the study of organisations that use science identify the work carried by one organisation;	• describe the work carried out in two organisations that use science;	• explain the importance of work that is carried out in two organisations that use science, these should be chosen from an international, a national and a local example;		
• identify where an organisation is located;	• identify one reason for the location of each of the two organisations;	• explain the location of the two organisations giving a minimum of one scientific, economic, social and environmental reasons;		**11**
• identify the job titles of people in the organisation;	• list the qualifications required by employees of the organisation;	• explain how the qualifications and skills enable the employees of the organisation enable them to carry out their role;		
• identify how the people in the organisation use science;	• describe how employees in the two organisations use science;	• relate the work carried out by the employees of the three organisations to the underpinning science;		
• the report has little structure or follows a structure provided by worksheets.	• the report is coherent and has an appropriate structure.	• the report is concise, logical and well sequenced, with appropriate use of textual and visual material.		

A typical candidate at grades GG, FF, EE will:	A typical candidate at grades DE to BC will:	A typical candidate at grades BB, AA, A*A* will:	Mark	Max
b1 • identify the type of chemical reaction used to obtain each product;	b2 • describe the type of chemical reaction used to obtain each product;	b3 • explain the underlying chemistry involved in each type of chemical reaction used to obtain each product, and explain the industrial importance in this, of this type of reaction;		
• identify the products and reactants of each reaction;	• write a word equation for each chemical reaction;	• write a balanced chemical equation for each chemical reaction;		
• follow step by step instructions to obtain products, using appropriate safety procedures;	• follow instructions to obtain products, using appropriate safety procedures;	• given a range of apparatus to choose from candidates are able to independently obtain their product;		**13**
• measure the yield of each product;	• carry out appropriate calculations to measure the actual yield and determine the percentage yield of each product given the theoretical yield;	• carry out appropriate calculations to determine quantities of reactants required, and the actual yield and percentage yield of each product;		
• give the reason(s) for the difference between the actual yield and percentage yield;	• describe the weaknesses of the technique used to produce each chemical product;	• identify sources of error and suggest improvements to the technique used to synthesise each product;		
• for one of these reactions, on an industrial scale, identify energy inputs and waste produced.	• for one of these reactions, on an industrial scale, list the energy inputs at each stage of the reaction and describe methods used to treat and dispose of waste.	• for one of these reactions, on an industrial scale, explain the energy inputs required at each stage and evaluate methods used to treat and dispose of waste.		

	A typical candidate at grades GG, FF, EE will:	A typical candidate at grades DE to BC will:	A typical candidate at grades BB, AA, A*A* will:	Mark	Max
c1	• identify the use of electronic or optical devices;	c2 • identify a range of components in these electronic or optical devices;	c3 • describe the functions of the components used in these electronic or optical devices;		
	• follow instructions to assemble an electronic or optical device with guidance following appropriate safety procedures;	• follow instructions to assemble an electronic or optical device, with some guidance, using appropriate safety procedures;	• assemble an electronic or optical device independently using appropriate safety procedures, selecting the most appropriate components for the device;		**7**
	• identify whether the device that they produced met the original brief.	• describe the weakness(es) of the device.	• describe the weakness(es) of the device and suggest improvements that could be made to over come them.		
d1	• identify simple types of mechanical devices;	d2 • identify a range of components in these mechanical devices;	d3 • explain how these components are used in mechanical devices;		
	• when given the components, follow instructions with guidance to assemble a mechanical device using appropriate safety procedures;	• follow instructions to assemble a mechanical device with little guidance, using appropriate safety procedures;	• investigate the performance of at least two mechanical devices, including one specified commercial device;		**6**
	• measure and record the forces applied and forces produced by a mechanical device.	• calculate the amount the device multiplies forces, the work done by the device and the efficiency of the device.	• carry out appropriate calculations to explain and evaluate the performance of at least two mechanical devices, including one specified commercial device.		

A typical candidate at grades GG, FF, EE will:	A typical candidate at grades DE to BC will:	A typical candidate at grades BB, AA, A*A* will:	Mark	Max
e1	e2	e3		
• identify the organism to be monitored;	• give reasons for monitoring the activity of the chosen organism;	• explain the importance of this monitoring process in a scientific context;		
• follow instructions to monitor the activity of an organism;	• produce a schedule for monitoring the activity of an organism;	• produce a detailed plan for monitoring the organism which defines the conditions that will be monitoring/controlling;		
• make and record simple observations and/or measurements with guidance;	• make and record accurate observations and/ or measurements independently;	• make and record sufficient accurate observations and/or measurements;		**13**
• present data in simple charts /graphs/images;	• process the data with some guidance where appropriate and present the data in a suitable format;	• manipulate the data independently using sophisticated techniques;		
• describe their findings;	• explain their findings using simple scientific knowledge and understanding;	• use a full and detailed understanding of the science involved to explain their findings;		
• identify any weaknesses of the monitoring process used.	• describe the effect of the weaknesses of the monitoring process used.	• review the work, identify sources of error and suggest improvements to their monitoring technique.		
Note: Although you will be given an interim mark out of 50 by your teacher, this might be adjusted by OCR to make sure that your mark is in line with national standards.			**Total**	**50**

Guidance for Teachers

Guidance on Delivery

In Unit 3, candidates will examine how scientific knowledge and understanding, along with underpinning practical skills are applied, both in the school and college laboratory and in the workplace. It is best delivered, therefore, integrated with the other two units, and using Unit 2 as the focal point. For example:

Unit 2 topic: Microorganisms

Unit 2 content	Unit 1 content	Unit 3 content
Cell theory	Microscopy:	Monitoring the activity of yeast
	Examination of yeast cells	How science is used in a brewery
Useful microorganisms	Culturing organisms: Aseptic culture of yeast	
Fermentation		
	Producing a food product	

Unit 2 topic: Chemical manufacture

Unit 2 content	Unit 1 content	Unit 3 content
Classify chemical compounds	Tests for cations and anions	
Identify examples of bulk and fine chemicals		
fertilizers	Separating dyes using chromatography	Laboratory preparation of:
pigments		
medicines		Ammonium sulfate
		Zinc oxide
		Iron (II) sulfate

Unit 2 topic: Metals

Unit 2 content	Unit 1 content	Unit 3 content
Properties of metals	Suitability of different metals for electrical cables	The generation of electricity and the power station
Relate structure to properties		
	Electrical properties of materials	
Links with the generation of electricity	Other physical properties (tensile strength, thermal conduction)	

In delivering this unit, due consideration must be made to the balance of the appropriate assessment objectives:

Assessment Objective	Balance
AO1: Knowledge and understanding of science and how science works	10%
AO2: Application of skills, knowledge and understanding	35%
AO3: Practical, enquiry and data-handling skills	55%

Note that in strands b, c, d and e, elements of planning are required for candidates working towards Mark Band 3. Candidates operating at lower mark bands will follow instructions to carry out the investigation.

Science in the Workplace

Science is involved in all aspects of our lives, and the intention is that this strand will provide candidates with an introduction to how science impacts on the society in which they live. An appreciation of how science is used in the outside world is best gained through industrial visits and work placements, presentations from and the opportunity to question visiting speakers, but where these are impracticable, secondary sources of information should be used. Industrial visits will also provide candidates with opportunities to research material for their Unit 1, working safely in science report.

Teachers might introduce the strand/unit by candidates' research of areas in which science is used. Suitable sources of information include the websites of the Institute of Biology, Institute of Physics and the Royal Society of Chemistry, along with advertisement sections of scientific periodicals and a review of the local Yellow Pages. This first exercise might comprise the introduction to the candidate's report on Science in the Workplace, or be a simple list or information leaflet.

In the major component of their report, candidates should demonstrate the appropriate depth of knowledge and understanding by investigating the science how science is used by a number of organisations. This should also consider other branches of science that have to be taken into consideration by the organisation, such as limiting the effects of their scientific practices on the environment. Local 'industry' should be engaged wherever possible, ands the strand should focus on any organisations, industries, services and practices where science is used, and not simply those that are overtly scientific. The help of local organisations, such as the fast food outlet or restaurant, hairdressing salon, garage, or parks department might therefore be enlisted. Scientific, environmental, economic and social reasons for the sighting of the industry should be researched, to include the availability and transport of raw materials, distribution of products, disposal of wastes, and provision of a public service. The growth of satellite industries, e.g. Marmite® and animal feed industries in association with the brewing industry could also be considered.

In this strand, it is possible that some candidates may extend their studies by accruing criteria towards Unit 1: Science at Work, of the OCR Advanced Subsidiary GCE in Applied Science (H175).

Making Useful Products

Based on the knowledge and understanding of chemical manufacture and rates of reaction in Unit 2: Science for the Needs of Society, and using the practical skills obtained in Unit 1: Developing Scientific Skills, (e.g. preparing chemical solutions of specified concentration, titration and separation of mixtures) candidates should appreciate chemicals that are important industrially are synthesized or manufactured by redox, neutralisation, precipitation and condensation/esterification reactions.

Examples of some experimental work might be:

Redox reactions – laboratory preparation of economically important metals from their ores, e.g. copper, or salts, e.g. iron (II) sulfate.

Link with Unit 2, Section 2.3, Extraction of metals; Section 2.3.3, Fine Chemicals

Neutralisation reactions – laboratory preparation of economically important compounds, e.g. ammonium sulfate or nitrate for the fertiliser industry.

Link with Unit 2, Section 2.1, Fertilisers and plants; Section 2.3.3, Bulk Chemicals

Precipitation reactions – laboratory preparation manufacture of economically important compounds, e.g. silver bromide/chloride for photographic industry.

Link with Unit 2, Section 2.3.3, Fine Chemicals

Condensation/esterification reactions – laboratory preparation of economically important esters for the flavour and perfume industries.

Link with Unit 2, Section 2.3.3, Fine Chemicals

Higher level candidates should calculate masses of reactants required and use skills from Unit 1 to make up their solutions. They should calculate theoretical yields and percentage yields independently.

The performance of candidates failing to produce two chemicals will be limited to Mark band 1 (one chemical reaction).

Electronic and Optical devices

Candidates have to assemble and assess the effectiveness of one electrical/electronic or optical device. Examples of devices to be constructed and tested might be:

- electronic – sensing, monitoring and control devices involving factors such as light and temperature
- optical – pin hole cameras, microscopes, terrestrial and astronomical telescopes, opera glasses, optical communication system (free space or optical fibre)

The device may be chosen to complement other areas of the specification, e.g. a device to control conditions in a glasshouse for optimum plant growth (Unit 2, Section 2.1); a device to control conditions in a fermenter (Unit 2, Section 2.1); an astronomical telescope (Unit 2, Section 2.6). It is important that the electronic and optical devices studied should be embedded within an applied context. In the context of uses in hospitals, examples of electronic devices could include security systems, communication systems, temperature controlled incubators, fluid level monitors, light level controllers and automatic door openers. Continuing this theme, optical devices used in this situation would include microscopes and fibre optic devices.

Mechanical Devices

Based on the knowledge and understanding of forces, energy and efficiency in Unit 2: Science for the Needs of Society, and using the practical skills obtained in Unit 1: Developing Scientific Skills, (e.g. collecting and recording data), candidates should appreciate the everyday use of mechanical devices.

Candidates should investigate the workings of one mechanical device and be given the opportunity to measure the forces applied and produced. Candidates who are able to make more progress will then move on to manipulate this data to calculate mechanical advantage, velocity ratios, and work outputs and inputs, where appropriate, and calculate the efficiency of their device (Mark Band 2) then use these calculations to evaluate the performance of their device (Mark Band 3).

At mark bands 1 and 2, candidates should construct and investigate systems of levers, pulleys or gears. At mark band 3, candidates should investigate and make measurements on commercial machines. Examples of devices to be investigated and tested might be:

- levers – used in lifting and hydraulic jacks; gym equipment;
- pulley systems – used in lifting; traction in hospitals;
- gear systems – used in machinery; clocks; bicycles.

Monitoring Living Organisms

At the simplest level, candidates should monitor an organism under controlled conditions; at Mark Bands 2 and 3 additional variables could be introduced, e.g. monitoring yeast growth at different temperatures. The activity must include planning at Mark Bands 2 and 3.

The organism under investigation should be important vocationally and may link to local circumstances, e.g. plant nursery, dairy farmer, sports' centre, brewery, etc, or to some other area of Unit 2. Such links may enable candidates to appreciate the economic importance of their monitoring exercise and allow the comparison of data collection at an industrial level. These industrial links must not, however, preclude the collection of primary data by candidates. While it is envisaged that most activities will involve biology of a physiological nature, organism behavioural studies could also be undertaken. It is important, however, that a study chosen must not be so esoteric as to prevent candidates making suitable comparisons with studies in the scientific literature and/or to research scientific explanations of the results.

The organism under investigation could be:

- a plant – monitoring the growth of a crop or horticultural plant. The effects of light, temperature and mineral elements could be investigated;
- a microorganism(s) – monitoring the growth of yeast or yogurt fermentation. The effects pH and temperature could be investigated;
- an animal – monitoring human activity. The effects of type of activity, level of fitness, load carried and state of fatigue could be investigated.

Guidance on Assessment

Each portfolio should be marked by the teacher according to the criteria in the Assessment Evidence Grid (page 72-75). Each row in the grid shows the hierarchical development of each criterion that makes up part of a strand. Each row corresponds to a point (a, b, c etc.) in the banner.

Please note that the second column describes the work of a typical candidate working at grades DE to BC whilst the third column describes the work of a typical candidate working at grades BB, to A*A*.

You use your professional judgment to determine which criterion in a strand best suits the individual candidate's work, using the Amplification of Criteria to help. The maximum mark for each strand is shown in the far right hand column of the grid. The mark for each strand is derived using Section Awarding of Marks guidance (pages 89-91).

Strand a		Science in the Workplace
Criterion	**Mark Band**	**Amplification of Criteria**
1	1	A list or information leaflet is produced identifying a range (>10) careers that involve the use of science.
2	1	Simple identification of one organisation that uses science.
	2	Description of the work carried out by two organisations that use science.
	3	Explanation of the work carried out in the two organisations. The organisations should include two from an international, national and a local example, though these do not have to pertain to the same type of industry.
3	1	Simple identification of where an organisation is located by identifying town, using address, or map, as appropriate.
	2	Identification of at least one reason for the location of each of the two organisations.
	3	Explains the location of each of the two organisations, giving a minimum of one scientific, economic, social or environmental reason for each.
4	1	A list of the job titles of people in the organisation.
	2	Description of the work carried out by a range of employees in each organisation.
	3	Explanation of the importance of the work carried out by a range of employees in each organisation, and the qualifications obtained/required and additional skills that have been acquired.
5	1	Identification of the science used by people in the organisation, limited to the scientific area involved.
	2	Description of the science used by employees in the two organisations, limited to specific area of the scientific discipline involved, e.g. genetics, and a general description of the scientific principles involved, e.g. uses understanding of genetics to develop improved strains of yeast.
	3	Explanation of the science underpinning the work involved in the two organisations, including the science knowledge and understanding involved, practical skills and the scientific principles behind the techniques used, where appropriate.
6	1	The candidate requires support/guidance in order to structure the report.
	2	The candidate produces a well structured report but requires guidance to select appropriate material.
	3	The candidate independently selects appropriate textual and visual material and structures a concise report.

Strand b		Making Useful Products
Criterion	**Mark Band**	**Amplification of Criteria**
1	1	Identification of the type of chemical reaction used to obtain each product.
	2	Description of the type of chemical reaction used to obtain each product.
	3	Use scientific knowledge and understanding to explain each type of chemical reaction, providing an relevant example of how the reaction is used in an industrial context.
2	1	For each type of chemical reaction, identify clearly the reactants and products.
	2	Independently write a word equation for each type of chemical reaction. This should be verified by teacher annotation.
	3	Independently write a balanced chemical symbol equation for each type of chemical reaction. This should be verified by teacher annotation.
3	1	Candidates require guidance to follow instructions safely to obtain products.
	2	Instructions are followed independently and safely obtain products. The level of independence is to be indicated on the candidates' portfolios by teacher annotation.
	3	Given a range of apparatus to choose from candidates are able to independently obtain their product. The level of independence is to be indicated on the candidates' portfolios by teacher annotation.
4	1	Candidates measure the yield of each product.
	2	Given appropriate information candidates then independently calculate actual yield and percentage yield. The level of independence is to be indicated on the candidates' portfolios by teacher annotation.
	3	Candidates independently calculate the quantities of reactants required for each chemical reaction. They produce the chemical then calculate the actual yield and percentage yield. The level of independence is to be indicated on the candidates' portfolios by teacher annotation.
5	1	With support, give a reason(s) for the difference between the actual yield and percentage yield.
	2	Describe any weaknesses of the technique or state clearly why there are no weaknesses.
	3	Identify sources of error related to accuracy and precision of measuring equipment and identify stages in the preparation and separation of the product where losses have occurred. Suggest improvements to overcome these sources of error or state why the technique did not contain any inherent weaknesses.

6	**1**	Describe simply the environmental impact of the industrial process of one of these reactions, limited to the energy inputs and waste produced.
	2	Expand on a description of the environmental impact listing all of the energy inputs and describing how waste products are treated and disposed of.
	3	Fully evaluate the environmental impact of the industrial process, explaining all of the energy inputs and how waste products are treated and disposed of.

Strand c		Electronic and Optical Devices
Criterion	**Mark Band**	**Amplification of Criteria**
1	1	Identification of how electronic or optical devices can be used.
	2	Referring to the devices in Mark Band 1, candidates identify a minimum of three components.
	3	Describe the function of the components from the devices referred to in Mark Band 1.
2	1	Candidates require guidance to follow instructions safely.
	2	Instructions are followed independently and safely. The level of independence is to be indicated on the candidates' portfolios by teacher annotation.
	3	Given a range of components to choose from candidates are able to choose independently to assemble their device. Higher level candidates should use practical investigation, e.g. the use of collimators, lenses and mirrors in construction of a free space optical system, or could carry out calculations to justify their selection of components, e.g. resistance calculations or the use of object to lens/mirror and lens/mirror to image distances in calculating focal lengths of lenses or mirrors and magnifications required. The level of guidance given by the teacher is to be indicated on portfolios by annotation.
3	1	Identify if the assembled device meets the brief provided by the teacher.
	2	Describe relevant weaknesses OR state clearly that there were no inherent weaknesses in their device.
	3	Make appropriate/ feasible suggestions for overcoming the weaknesses identified in Mark Band 2 OR state why the device worked so effectively. These improvements could relate to the portability and durability of the device, but should also include a scientific basis, e.g. the selection of alternative processors to give a more effective switching device; refractive indices of lens glass; chromatic and spherical aberration.

Strand d		Mechanical Devices
Criterion	**Mark Band**	**Amplification of Criteria**
1	1	Identification of a minimum of two types of mechanical device.
	2	Identify a minimum of three components that contribute to the functioning of mechanical devices.
	3	For each component referred to in Mark Band 2, explain how it is used in the devices identified in Mark Band 1.
2	1	Candidates require guidance to follow instructions safely to assemble simple levers, pulley or gear systems.
	2	Instructions are followed with some guidance and safely. The level of independence is to be indicated on the candidates' portfolios by teacher annotation.
	3	Given a range of components to choose from candidates are able to choose independently to assemble their device. Devices could include systems of levers, pulleys or gears. The level of independence is to be indicated on the candidates' portfolios by teacher annotation. Level 3 candidates should also make measurements on a specified device, for example a car jack or gym equipment.
3	1	For the device assembled measure and record the forces applied and produced.
	2	With guidance, calculate how well the device acts as a force multiplier and the work and efficiency of the device assembled.
	3	Use calculations to explain and evaluate the performance of the device assembled.

Strand e		Monitoring Living Organisms
Criterion	**Mark Band**	**Amplification of Criteria**
1	1	Identification of the organism to be monitored.
	2	Identification of pertinent reasons for monitoring the organism, related to (but are not required to specify at this level) the optimum production/performance and/or scientific research.
	3	Explanation of pertinent reasons for monitoring the organism specified, related to the economic importance of the organism, where appropriate, optimum production or performance and/or scientific research.
2	1	Follow given instructions to monitor the activity of the organism.
	2	Produce a simple monitoring schedule for the investigation, identifying the measurements/observations to be taken, times or intervals when they are taken and the duration of the investigation.
	3	Produce a detailed plan of the investigation, defining independent and dependent variables, how these variables will be controlled, explaining the range over which independent variables will be investigated and defining the duration of the investigation.
3	1	Make and record simple observations/measurements using writing frames where required. The level of guidance given to the candidate should be indicated on the portfolio by teacher annotation.
	2	Make and record accurate observations/measurements independently. Level of accuracy and independence to be indicated on the candidate’s portfolio by teacher annotation.
	3	Make and record sufficient accurate observations/measurements to ensure ‘scientific validity’ of data. Level of accuracy and independence to be indicated on the candidate’s portfolio by teacher annotation.
4	1	Present data in simple charts and/or graphs and photographic and digital images using writing frames and with teacher guidance where required. The level of guidance given to the candidate should be indicated on the portfolio by teacher annotation.
	2	Process data, e.g. by calculating means; pulse beats min-1; substitution into simple formulae, and present the data in a suitable format with some teacher guidance. The level of guidance given to the candidate should be indicated on the portfolio by teacher annotation.
	3	Manipulate the data using sophisticated techniques, e.g. calculate concentrations of cells from haemacytometer counts; production of calibration curves and interpolation of data; and titration calculations to measure concentration of ions in the environment, etc. The level of independence shown by the candidate should be indicated on the portfolio by teacher annotation.

5	1	Simple description of findings, e.g., the yeast increased in mass because of its growth and reproduction over a five day period.
	2	Explanation of findings using simple knowledge and understanding, e.g., the optimum temperature for the growth of the microorganism was 37°C because this is the optimum activity for enzyme activity.
	3	Explanation of findings using a full and detailed understanding of the science involved, e.g., an explanation for the increase in growth rate of a microorganism with increase in temperature, an optimum temperature for growth, and a decrease in growth rate related to the mechanism of enzyme action.
6	1	Simple identification of weaknesses of the monitoring process, e.g., difficulties in making measurements.
	2	Identification of the weaknesses involved in the monitoring process and the effect on the data produced.
	3	Review of work, discussing the validity of the data and the conclusions that can be drawn from it. A statistical consideration could be made by some candidates. Identification of sources of error, including errors from experimental design, accuracy and precision of monitoring equipment, and random error. Links sources of error with suggested improvements to monitoring technique.

Awarding of Marks

Refer to the Assessment Evidence Grid (pages 72-75). The criteria are hierarchical. Marks may be awarded as follows:

Strand a	**A report on How Science is Used in The Workplace**
Mark Band	
Band 3: 9-11 marks	11 marks for **five** criteria at mark band 3 10 marks for **four** criteria at mark band 3; the **other** criterion completed at mark band 2 9 marks for **two or three** criteria at mark band 3; the **other** criterion completed at mark band 2
Band 2: 6-8marks	8 marks for **five** criteria at least mark band 2 7 marks for **four** criteria at least mark band 2; the **other** criterion completed at mark band 2 6 marks for **two** or **three** criteria at least mark band 2
Band 1: 0-5 marks	5 marks for **six** criteria at mark band 1 4 marks for **five** criteria at mark band 1 3 marks for **four** criteria at mark band 1 2 marks for **two or three** criteria at mark band 1 1 marks for **one** criteria at mark band 1

Strand b	**The production of pure, dry samples from two types of chemical reaction**
Mark Band	
Band 3: 10-13 marks	13 marks for **six** criteria at mark band 3 12 marks for **five** criteria at mark band 3; the **other** criterion completed at mark band 2 11 marks for **four or three** criteria at mark band 3; the **other** criteria completed at mark band 2 10 marks for **one or two** criteria at mark band 3; the **other** criteria completed at mark band 2
Band 2: 6-9 marks	9 marks for **six** criteria at least mark band 2 8 marks for **five** criteria at least mark band 2; the **other** criterion completed at mark band 1 7 marks for **four** or **three** criteria at least mark band 2; the **other** criterion completed at mark band 1 6 marks for **one** or **two** criteria at least mark band 2; the **other** criterion completed at mark band 1
Band 1: 0-5 marks	5 marks for **six** criteria at mark band 1 4 marks for **five** criteria at mark band 1 3 marks for **four** criteria at mark band 1 2 marks for **three** criteria at mark band 1 1 marks for **one or two** criteria at mark band 1

Strand c	A report on the assembly and assessment of the effectiveness of one electronic / or electrical or optical device
Mark Band	
Band 3: 6-7 marks	7 marks for **three** criteria at mark band 3 6 marks for **one or two** criteria at mark band 3; the **other** criterion completed at mark band 2
Band 2: 3-5 marks	5 marks for **three** criteria at least mark band 2 4 marks for **two** criteria at least mark band 2; the **other** criterion completed at mark band 1 3 marks for one criterion at mark band 2; the other criteria completed to mark band 1
Band 1: 1-2 marks	2 marks for **three** criteria at mark band 1 1 marks for **one or two** criteria at mark band 1

Strand d	A report on mechanical devices
Mark Band	
Band 3: 5-6 marks	6 marks for **three** criteria at mark band 3 5 marks for **one or two** criteria at mark band 3; the **other** criterion completed at mark band 2
Band 2: 3-4 marks	4 marks for **three** criteria at least mark band 2 3 marks for **one** criteria at least mark band 2; the **other two** criterion completed at mark band 1
Band 1: 1-2 marks	2 marks for **three** criteria at mark band 1 1 marks for **one or two** criteria at mark band 1

Strand e Mark Band	A report on Monitoring the growth / development / response of an organism
Band 3: 9-13 marks	13 marks for **six** criteria at mark band 3 12 marks for **five** criteria at mark band 3; the **other** criteria completed at mark band 2 11 marks for **four** criteria at mark band 3; the **other** criteria completed at mark band 2 10 marks for **three** criteria at mark band 3; the **other** criteria completed at mark band 2 9 marks for **one or two** criteria at mark band 3; the **other** criteria completed at mark band 2
Band 2: 5-8 marks	8 marks for **six** criteria at least mark band 2 7 marks for **five** criteria at least mark band 2; the **other two** criterion completed at mark band 1 6 marks for **four or three** criteria at mark band 2; the other criteria to mark band 1. 5 marks for **one or two** criteria at mark band 2; the other criteria completed to mark band 1
Band 1: 0-4 marks	4 marks for **five** criteria at mark band 1 3 marks for **four** criteria at mark band 1 2 marks for **three** criteria at mark band 1 1 marks for **one or two** criteria at mark band 1

Student Record: OCR Double Award Applied Science

Candidate:

Unit 3 **Science at Work**

	Strand a			
	Science in the Work Place			
Criterion				Mark Band
1	Identify careers			
2	Work carried out by organisation			
3	Location of organisation			
4	Job titles and qualifications			
5	Use of science			
6	Quality of report			
		Total		

	Strand b			
	Chemical Reactions			
Criterion		Level		Mark Band
		Reaction		
		1	2	
1	Type or reaction			
2	Products and reactants/equation			
3	Obtain product			
4	Calculation of yields			
5	Evaluation			
6	Energy inputs/disposal of waste			
		Total		

	Strand c		
	Electronic / Optical Device		
Criterion			Mark Band
1	Uses of electronic/optical devices		
2	Assemble device		
3	Evaluate device		
		Total	

Strand d		
Mechanical Device		
Criterion		Mark Band
1	Types of mechanical devices and components	
2	Assemble/ investigate performance	
3	Calculations of performance	
	Total	

Strand e		
Monitoring an Organism		
Criterion		Mark Band
1	Identify organism	
2	Produce plan/ monitor organism	
3	Record measurements/ observations	
4	Present and process data	
5	Explain findings	
6	Evaluate monitoring process	
	Total	

Resources

This specification is supported by OCR approved Heinemann Texts.

GCSE in Applied Science for OCR

John Beeby, Jackie Clegg, David Lees, Chris Sherry

Heinemann Educational Secondary Division

Other texts include:

GCSE in Applied Science Double Award
Colin Bell, David Brodie, Byron Dawson, Ann Tiernan
Folens Publishers

Applied Science: GCSE Double Award series
Stewart Chenery, Tracey Chappell, Anna Holmes, Beverly Rickwood, Steve Unsworth
Hodder Murray

Applied Science GCSE

Ken Gadd
Nelson Thornes

The Complete Course to support the GCSE in Applied Science (Double Award)

4 Science Education and Training

Websites include:

Beeby Education

www.beeby-education.co.uk

Channel 4

http://www.channel4.com/learning/microsites/G/gcsease/free_areas/science/index.html

LSDA

http://www.vocationallearning.org.uk/tutorials/

University of Warwick/CEI; Learning and Skills Development Agency

http://www.vocationallearning.org.uk/staff/cei

(available as free CD-ROM)

SEMTA

http://www.gcseinappliedscience.com

4 Scheme of Assessment

4.1 Units of Assessment

GCSE Applied Science (Double Award) (J649)	
Unit 1: Developing Scientific Skills (B481)	
33.3% of the total GCSE marks Portfolio 50 marks	This portfolio assessment is assessed by teachers, internally standardised and then externally moderated by OCR.
	Only evidence that meets the requirements of the assessment should be included in this portfolio.
Unit 2: Science For The Needs of Society (B482)	
33.3% of the total GCSE marks 1 hr written paper 60 marks	This question paper: • Is offered in Foundation and Higher Tiers
	• Uses structured questions throughout (there is no choice of questions)
	• Assesses the knowledge and understanding of the content of Unit 2 and the application of the knowledge and understanding
Unit 3: Science at Work (B483)	
33.3% of the total GCSE marks Portfolio 50 marks	This portfolio assessment is assessed by teachers, internally standardised and then externally moderated by OCR.
	Only evidence that meets the requirements of the assessment should be included in this portfolio.

4.2 Unit Options

There are no unit options within this specification.

4.3 Tiers

The externally assessed unit, Unit 2, is offered at Foundation and Higher Tiers.

The Foundation Paper is targeted at grades C to G.
The Higher Paper is targeted at grades A* to D. An allowed grade E may be awarded on the Higher Tier.

The final qualification grade awarded will be independent of tier and based on the UMS score.

4.4 Assessment Availability

There are two examination sessions each year, in January and June.

External assessment (Unit 2), is available every January and June from June 2007.

Portfolio moderation (for Units 1 and 3) is available every January and June from January 2008.

First certification will be available in June 2008 and every January and June thereafter.

4.5 Assessment Objectives

Assessment objective 1 (AO1): Knowledge and understanding of science and how science works

Candidates should be able to:

a) demonstrate knowledge and understanding of the scientific facts, concepts, techniques and terminology in the specification

b) show understanding of how scientific evidence is collected and its relationship with scientific explanations and theories

c) show understanding of how scientific knowledge and ideas change over time and how these changes are validated.

Assessment objective 2 (AO2): Application of skills, knowledge and understanding

Candidates should be able to:

a) apply concepts, develop arguments or draw conclusions related to familiar and unfamiliar situations

b) plan a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem

c) show understanding of how decisions about science and technology are made to different situations, including contemporary situations and those raising ethical issues

d) evaluate the impact of scientific developments or processes on individuals, communities or the environment

Assessment objective 3 (AO3): Practical, enquiry and data-handling skills

Candidates should be able to:

a) carry out practical tasks safely and skillfully

b) evaluate the methods they use when collecting first-hand and secondary data

The weightings for the assessment objectives over the whole qualification are:

Assessment Objective	Weighting
AO1	28%
AO2	35%
AO3	37%

	Unit 1	Unit 2	Unit 3
AO1	10%	63%	15%
AO2	35%	33%	35%
AO3	55%	4%	55%
	100%	100%	100%

4.6 Quality of Written Communication

Quality of written communication is assessed in Units 1 and 3 and credit may be restricted if communication is unclear.

Candidates should:

- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
- present information in a form that suits its purpose;
- use a suitable structure and style of writing.

5 Internal Assessment

5.1 Marking Internally Assessed Work

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 GCSE 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 on 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 of these may be obtained from the OCR Subject Officer.

Determining a Candidate's Mark

Each unit portfolio should be marked by the teacher according to the criteria in the Assessment Evidence Grid. Each row in the grid comprises a strand showing the development of a given criterion and corresponds to a point (a, b, c etc.) in the banner.

Each column describes the work undertaken by a candidate working within a range of grades. The criterion in the first column describes typical attainment of a candidate working within the range of grades GG to EE. The second column describes the work of a typical candidate working at grades DE to BC whilst the third column describes the work of a typical candidate working at grades BB to A*A*.

The maximum mark for that strand is shown in the right hand column.

Teachers use their professional judgement to determine the mark that best fits the work of the candidate and also record it in the column headed Mark.

Centres should use the full range of marks available to them; centres must award full marks in any band for work which fully meets the criteria. This is work which is 'the best one could expect from candidates working at GCSE (Double Award) level'.

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.

Centres may find it helpful to use the assessment criteria holistically when initially assessing candidates' work. The outcome can then be compared with the final grade awarded through the procedure outlined above. If these differ, an explanation should be sought and the differences resolved.

5.2 Regulations for Internally Assessed Work

Supervision and Authentication of Portfolios

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. Teachers may set internal deadlines for candidates submitting work to them. 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. Internal Assessors must record details of any assistance given and this must be taken into account when assessing candidates' work. Once the mark for the unit portfolio has been submitted to OCR, no further work may take place.

Production and Presentation of Portfolios

Candidates 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.

Work submitted for moderation must be marked with the:

- centre number;
- centre name;
- candidate number
- candidate name;
- specification code and title;
- unit code.

All work submitted for moderation should be removed from cardboard files, ring binders and plastic wallets. Work must be held together by using treasury tags or an appropriate alternative (not paper clips).

Prepared samples in Unit 3: Science at Work should not be sent with the portfolio. Annotation that the sample was prepared is sufficient evidence.

Administering Portfolio Assessment

OCR will conduct all administration of the GCSEs in vocational subjects 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 Record materials, including full details of administrative arrangements for portfolio assessment, will be forwarded to Examination Officers in Centres, following receipt of provisional entries. At the same time the materials will be made available on the OCR website (www.ocr.org.uk). The materials will include master copies of mandatory forms on which to record assessments and will also include optional recording materials for the convenience of Centres. Forms may be photocopied and used as required.

The Assessment Evidence Grids

Centres are required to carry out internal assessment of portfolios using the Assessment Evidence Grids in accordance with OCR procedures. The process of using these grids is described in the *Guidance on Assessment* sections of Units 1 and 3. Candidates' marks are recorded on these grids. One grid should be completed for each candidate's unit portfolio. These grids should be attached to the front of the candidate's portfolio for the unit when sent to the Moderator.

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

Candidates' portfolios should be clearly annotated to demonstrate where, and to what level, criteria have been achieved. This will help in the moderation process. If teachers do this well it will be very much in the interests of their candidates. On completion of a unit, the teacher must complete the Assessment Evidence Grid and award a mark out of 50 for the unit.

Internal Standardisation

It is important that all internal assessors, working in the same subject area, work to common standards. Centres are required to ensure that internal standardisation of marks across teaching groups takes place using an appropriate procedure.

This 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.

Submission of Marks to OCR

The involvement of OCR begins on receipt of entries for a portfolio unit from a Centre's Examinations Officer. Entries for units to be included in any assessment session must be made by the published entry date from OCR. Late entries attract a substantial penalty fee.

By an agreed internal deadline the teacher submits the marks for the unit to the Examinations Officer. Marks will need to be available by the portfolio mark submission dates published by OCR and internal deadlines will need to reflect this. 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.

Moderation

Moderation will be available, by post in January and June. Shortly after receiving the marks, the Moderator will contact the Centre and inform them of the sample of candidates' work that will be required.

After the unit portfolio is internally marked by the teacher and marking has been internally standardised, marks are submitted to OCR by a specified date, published in the Key Dates poster, after which moderation takes place in accordance with OCR procedures.

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

It is essential that the rank order of marks supplied to a Moderator is correct. If Centre assessment is inconsistent, work will be returned to the Centre for re-assessment.

The sample of work which is presented to the Moderator for moderation must show how the marks have been awarded in relation to the marking criteria defined in the unit.

Moderation for all units will be available in the January and June sessions.

Principles of Moderation

The following principles, agreed by the Awarding Bodies and QCA, indicate, in broad terms, how portfolio units will be moderated. OCR has detailed procedures that Moderators will follow to implement the moderation process.

Centres submit unit marks to OCR and to the Moderator by the published OCR submission date.

The Moderator will select from each unit, a sample of candidates' portfolios which cover a range of grades.

If the work seen overall has been assessed accurately and consistently to agreed national standards, within agreed tolerances, all unit marks submitted by the Centre are accepted with no adjustments.

Adjustments, where required, will be carried out by OCR using its normal procedure. Centres are not required to amend marks except if administrative issues, errors or order of merit problems are discovered.

Whilst Moderators may seek clarification from a Centre, they cannot negotiate portfolio marks in any way. OCR will inform Centres of the outcome of the moderation process at the time of publication of results. This will include a written report on any significant issues that arose during this process

6 Technical Information

6.1 Making Unit Entries

Please note that centres must be registered with OCR in order to make any entries, including estimated entries. It is recommended that centres apply to OCR to become a registered centre well in advance of making their first entries. Centres should be aware that a minimum of ten candidates for summer examinations is normally required.

Unit Entry Options

Within Unit 2 candidates must be entered for either the Foundation Tier or the Higher Tier option. Candidates may, if they wish, attempt papers at both tiers, but not in the same examination session, since the papers will be timetabled simultaneously.

Unit	Entry/Option Code	Title	Component	Duration
2	B482F	Foundation Tier	01	1 hour
2	B482H	Higher Tier	02	1 hour

6.2 Making Qualification Entries

Note that entry for units will not generate a final certificate – a separate certification entry for code **J649** must be made. This will usually be along with the final unit entries.

A candidate who has completed all the units required for a qualification may enter for certification at a later examination series. For example, a candidate who has completed all the required units but who has not entered for certification may do so in the same examination series within a specified period after the publication of results.

First certification will be available in June 2008 and every January and June thereafter.

6.3 Grading

GCSE results are awarded on the scale A*-G. Units are awarded a* to g. Grades are awarded on certificates. Results for candidates who fail to achieve the minimum grade (G or g) will be recorded as *unclassified* (U or u).

In modular schemes candidates can take units across several different sessions. They can also re-sit units or choose from optional units available. When working out candidates' overall grades OCR needs to be able to compare performance on the same unit in different sessions when different grade boundaries have been set, and between different units. OCR uses uniform marks to enable this to be done.

A candidate's uniform mark is calculated from the candidate's raw mark. The raw grade boundary marks are converted to the equivalent uniform mark boundary. Marks between grade boundaries are converted on a pro rata basis.

When unit results are issued, the candidate's unit grade and uniform mark are given. The uniform mark is shown out of the maximum uniform mark for the unit e.g. 73/100

Results for each unit will be published in the form of uniform marks. Each unit in this specification has a uniform mark of 100.

Uniform marks correspond to unit grades as follows:

	Unit 1	Unit 2		Unit 3
		Foundation	Higher	
Max	100	69	100	100
a*	90	N/A	90	90
a	80	N/A	80	80
b	70	N/A	70	70
c	60	60	60	60
d	50	50	50	50
e	40	40	40	40
f	30	30	N/A	30
g	20	20	N/A	20

The uniform marks awarded for each unit will be aggregated and compared to pre-set boundaries. Results for the qualification will be awarded on a scale of A*A* to GG and will be recorded twice on the certificate as such.

The final qualification grade awarded will be independent of tier.

6.4 Result Enquiries and Appeals

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

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

6.5 Shelf-Life of Units

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

6.6 Unit and Qualification Re-sits

Candidates may re-sit any unit an **unlimited** number of times.

For each unit the best score will be used towards the final overall grade.

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

6.7 Guided Learning Hours

GCSE Applied Science (Double Award) requires 180 guided learning hours in total.

6.8 Code of Practice/Subject Criteria/Common Criteria Requirements

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

6.9 Arrangements for Candidates with Particular Requirements

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

6.10 Prohibited Qualifications and Classification Code

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

Due to overlap of content, candidates may not enter for GCSE Science in the same examination session. This restriction, if not prevented at the point of entry, will be picked up both when funding is calculated and when results leading to points towards performance tables are aggregated, as all of the above qualifications will have the same classification code and so be discounted for funding and performance table purposes. The classification code for this qualification is 0008.

7 Other Specification Issues

7.1 Overlap with other Qualifications

This specification broadly introduces the candidate to skills relevant to a range of Science 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 is available from QCA.

All units broadly contribute knowledge, understanding and skills for NVQs in Science at Levels 1 and 2.

This specification complies fully with the Key Stage 4 programme of study GCSE criteria for Science.

7.2 Progression from these Qualifications

Progression into Employment

This specification is designed to enable candidates to enter employment at operative or technician level within a wide range of science environments. For example, as medical technicians, pharmaceutical technicians or laboratory technicians, in industry, service sectors or education. Such candidates would normally enter employment through a work-related training programme.

The science sector is an important area of employment and the well developed personal skills (e.g. initiative, teamwork, problem-solving) combined with work-related knowledge gained within a GCSE (Double Award) means that candidates are particularly suitable for recruitment in a range of employment categories, e.g. manufacturing, processing, food, health.

Progression to Further Qualifications

Candidates who achieve this qualification at Level 1 may wish to continue to courses such as an OCR National award or NVQ in a science related subject at Level 1, or, if suitably qualified in other areas, could progress to courses such as an OCR National award Science or an NVQ in a science related subject at Level 2.

Candidates who achieve this qualification at Level 2 may wish to continue to courses such as an OCR National award or, could progress to courses leading to a GCE or NVQ Level 3 qualification in a science related subject.

A GCSE (Double Award) qualification may also be considered as equivalent to two GCSEs at grades A* to G for the purposes of admission to other level courses within the National Qualifications Framework, including GCSEs in other vocational areas.

7.3 ICT

In order to move on to more advanced study of science, candidates need to be confident and effective users of ICT. This specification provides candidates with a wide range of appropriate opportunities to use ICT in order to further their study of Science.

Opportunities for ICT include:

- gathering information from the Internet and CD-ROMs;
- gathering data using sensors linked to data-loggers or directly to computers;
- use of videos clips to show standard procedures in the workplace and the applications of science at work
- using spreadsheets and other software to process data;
- using animations and simulations to visualise scientific ideas;
- using software to present ideas and information on paper and on screen..

The examples listed in the table below show some points in the specification where opportunities might more easily be found.

Particular opportunities for the use of ICT are highlighted in the introductions to the modules.

7.4 Citizenship

From September 2002, the National Curriculum for England at Key Stage 4 includes a mandatory programme of study for Citizenship. Parts of the programme of study may be delivered through an appropriate treatment of other subjects.

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

The purpose of the following table is to signpost possible opportunities for delivering Citizenship related issues.

Unit	Content
1	Working safely in science.
2	The use of nuclear fuels, recycling and energy saving.
3	None.

7.5 Key Skills

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 1 and/or 2. 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 1 and/or 2 for each unit.

Unit	C				AoN			IT			WwO			IoLP			PS		
	.1a	.1b	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3	.1	.2	.3
1	✓	✓	✓	✓				✓	✓		✓						✓	✓	✓
2		✓	✓	✓				✓	✓	✓	✓						✓	✓	✓
3																			

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

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

It is expected that this specification will be presented in ways which provide opportunities to address these issues in relation to the acceptability of scientific ideas and technological developments.

Some of these opportunities are highlighted below.

The ethical and moral implications of some of the applications of science and technology may be addressed in Unit 1: Developing scientific skills, detecting the presence of banned substances or alcohol, Unit 2: Science for the needs of society, farming methods and genetic engineering, obtaining useful substances and Unit 3: Science at work, monitoring living things.

Opportunities for teaching a sense of awe and wonder at the atomic and molecular workings of the material world occur in Unit 1: Developing scientific skills, how substances enter and leave cells, the composition of a solution, suspension, gel, emulsion, foam and aerosol and Unit 2: Science for the needs of society, exothermic and endothermic reactions, the structure of the atom, the structure of metals, polymers, ceramics and materials, plant mineral requirements, chemical formulae.

Also Unit 2: Science for the needs of society investigates the implications for the storage and reprocessing of radioactive material.

Opportunities for teaching the issue of pollution exists in Unit 2: Science for the needs of society, living organisms obtaining useful chemicals and the importance of energy.

Legal issues are addressed in each unit, where appropriate.

The purpose of the table below is to signpost further possible opportunities for assessing Spiritual, Moral, Ethical, Social and Cultural (SMESC) related issues.

Key: **Sp** Spiritual **M** Moral **E** Ethical **So** Social **C** Cultural

Unit	Content	Sp	M	E	So	C
1	Working safely in science introduces social responsibility: **So.**				*	
	Working with substances/experiments and radioactivity, working with living organisms and in discussing the use of banned substances will introduce **Sp M E** issues in terms of potential obligation from different groups of people.	*	*	*		
	Dealing with unwanted materials and their safe disposal: **So**				*	
	Recording accurate results, not copying others, and working collaboratively in experiments and sharing results: **M E** So will come via the		*	*	*	
2	The scientific production of goods meeting needs of Society: **So.**				*	
	Working with living organisms: **Sp M E.**	*	*	*		
	The use of fossil fuels and the use of nuclear fuels, recycling and energy saving: **So.**				*	
	Recognition of the intensive/organic farming and genetic engineering debate: **M E So.**		*	*	*	
	Immunisation and the killing of some bacteria: **So**.				*	
	The ethical use and recognition/citation of source information: **E.**			*		
3	The use of science to benefit Society and working in a socially responsible manner: **So.**				*	
	Monitoring living organisms: **Sp M E So.**	*	*	*	*	
	Ethical use and recognition/citation of source information: **E.**			*		

7.7 Sustainable Development, Health and Safety Considerations and European Developments

Environmental Issues

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.

Unit 2: Science for the needs of society is specifically designed to consider the environmental issues associated with different farming methods.

The purpose of the following table is to signpost further possible opportunities for delivering environment related issues.

Unit	Content
1	Dealing with unwanted materials and their safe disposal.
2	The use of fossil fuels. Recognition of the intensive/organic farming and genetic engineering debate. Immunisation and the killing of some bacteria.
3	None.

The European Dimension

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.

Whilst at this level, local and national issues will predominate, teachers are expected to take appropriate opportunities to consider issues in the European context. The study of different farming methods in Unit 2: Science for the needs of society provides the opportunity to consider these issues.

The purpose of the following table is to signpost further possible opportunities for delivering European related issues.

Unit	Content
1	Working safely/within legal framework in science. Working with living organisms and discussing the use of banned substances. Dealing with unwanted materials and their safe disposal. Fire regulations and standard operating procedures.
2	Working with living organisms. The use of nuclear fuels, recycling and energy saving. Recognition of the intensive/organic farming and genetic engineering debate. Immunisation and the killing of some bacteria: possible European dimension re. Copyright and use of materials.
3	Monitoring living organisms. Skills and qualifications required to operate in this field, also the governing of the functionality of instruments and machines.

Health and Safety

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.

Unit 1: Developing scientific skills is specifically designed to consider the health and safety issues associated with practical work within a science environment.

7.8 Avoidance of Bias

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

7.9 Language

These specifications and associated assessment materials are in English only.

Appendix A: Performance Descriptions

The following grade descriptions indicate the levels of attainment characteristic of the given grade for this GCSE (Double Award). They give a general indication of the required standard at each specified grade. The descriptions should be interpreted in relation to the content and assessment evidence requirements outlined in the specification; they are not designed to define that content. The grade awarded will depend, in practice, upon the extent to which the candidate has met the assessment evidence requirements overall. Shortcomings in some aspects of the assessment may be balanced by better performances in others.

Grade F

Candidates demonstrate a limited knowledge and understanding of science content and how science works. They use a limited range of the concepts, techniques and facts from the specification, and demonstrate basic communication and numerical skills, with some limited use of technical terms and techniques.

They show some awareness of how scientific information is collected and that science can explain many phenomena.

They use and apply their knowledge and understanding of simple principles and concepts in some specific contexts. With help they plan a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem, using a limited range of information in an uncritical manner. They are aware that decisions have to be made about uses of science and technology and, in simple situations familiar to them, identify some of those responsible for the decisions. They describe some benefits and drawbacks of scientific developments with which they are familiar and issues related to these.

They follow simple instructions for carrying out a practical task and work safely as they do so.

Candidates identify simple patterns in data they gather from first-hand and secondary sources. They present evidence as simple tables, charts and graphs, and draw simple conclusions consistent with the evidence they have collected.

Grade C

Candidates demonstrate a good overall knowledge and understanding of science content and how science works, and of the concepts, techniques, and facts across most of the specification. They demonstrate knowledge of technical vocabulary and techniques, and use these appropriately. They demonstrate communication and numerical skills appropriate to most situations.

They demonstrate an awareness of how scientific evidence is collected and are aware that scientific knowledge and theories can be changed by new evidence.

Candidates use and apply scientific knowledge and understanding in some general situations. They use this knowledge, together with information from other sources, to help plan a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem.

They describe how, and why, decisions about uses of science are made in some familiar contexts. They demonstrate good understanding of the benefits and risks of scientific advances, and identify ethical issues related to these.

They carry out practical tasks safely and competently, using equipment appropriately and making relevant observations, appropriate to the task. They use appropriate methods for collecting first-hand and secondary data, interpret the data appropriately, and undertake some evaluation of their methods.

Candidates present data in ways appropriate to the context. They draw conclusions consistent with the evidence they have collected and evaluate how strongly their evidence supports these conclusions.

Grade A

Candidates demonstrate a detailed knowledge and understanding of science content and how science works, encompassing the principal concepts, techniques, and facts across all areas of the specification. They use technical vocabulary and techniques with fluency, clearly demonstrating communication and numerical skills appropriate to a range of situations.

They demonstrate a good understanding of the relationships between data, evidence and scientific explanations and theories. They are aware of areas of uncertainty in scientific knowledge and explain how scientific theories can be changed by new evidence.

Candidates use and apply their knowledge and understanding in a range of tasks and situations. They use this knowledge, together with information from other sources, effectively in planning a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem.

Candidates describe how, and why, decisions about uses of science are made in contexts familiar to them, and apply this knowledge to unfamiliar situations. They demonstrate good understanding of the benefits and risks of scientific advances, and identify ethical issues related to these.

They choose appropriate methods for collecting first-hand and secondary data, interpret and question data critically, and evaluate the methods they use. They carry out a range of practical tasks safely and competently, selecting and using equipment appropriately to make relevant and precise observations.

Candidates select a method of presenting data appropriate to the task. They draw and justify conclusions consistent with the evidence they have collected and suggest improvements to the methods used that would enable them to collect more valid and reliable evidence.

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Appendix B: Requirements Relating to Mathematics

During the course of study for this specification, many opportunities will arise for quantitative work, including appropriate calculations. The mathematical requirements which form part of the specification are listed below. Items in the first table may be examined in written papers covering both Tiers. Items in the second table may be examined only in written papers covering the Higher Tier.

Both Tiers
add, subtract, multiply and divide whole numbers
recognise and use expressions in decimal form
make approximations and estimates to obtain reasonable answers
use simple formulae expressed in words
understand and use averages
read, interpret, and draw simple inferences from tables and statistical diagrams
find fractions or percentages of quantities
construct and interpret pie-charts
calculate with fractions, decimals, percentage or ratio
solve simple equations
substitute numbers in simple equations
interpret and use graphs
plot graphs from data provided, given the axes and scales

Higher Tier only
recognise and use expressions in standard form
manipulate equations
select appropriate axes and scales for graph plotting
determine the intercept of a linear graph
understand and use inverse proportion
calculate the gradient of a graph
statistical methods e.g. cumulative frequency, box plots, histograms

Appendix C: Physical Quantities and Units

You need to know how to measure and/or calculate the following quantities, using the correct units and their symbols:

Quantity	Units/symbols
mass	kilogram/kg gram/g milligram/mg microgram/μg
length	kilometre/km metre/m centimetre/cm millimetre/mm micrometre/μm
volume	cubic metre/m^3 cubic decimetre/dm^3 litre/l cubic centimetre/cm^3 millilitre/ml
time	Hour/h minute/min second/s
temperature	degrees Celsius/°C
chemical quantity	Mole/mol
potential difference (voltage)	Volt/V
current	Ampere/A milliampere/mA
resistance	Ohm/Ω kilohm/kΩ megohm/MΩ
force	Newton/N
energy/work	Kilojoule/kJ joule/J kilowatt-hour/kWh
power	Kilowatt/kW watt/W
density	gram per cubic centimetre/g cm^{-3} kilogram per cubic metre/kg m^{-3}

Appendix D: Chemical Symbols and Formulae

Metals		Non-Metals	
Element	Chemical Symbol	Element	Chemical Symbol
Aluminium	Al	Aluminium	Al
Barium	Ba	Barium	Ba
Calcium	Ca	Calcium	Ca
Iron	Fe	Iron	Fe
Lead	Pb	Lead	Pb
Magnesium	Mg	Magnesium	Mg
Potassium	K	Potassium	K
Silver	Ag	Silver	Ag
Sodium	Na	Sodium	Na
Zinc	Zn	Zinc	Zn

You need to know the names and formulae of the following chemical compounds:

Compound	Formula	Compound	Formula
Ammonia	NH_3	Barium chloride	$BaCl_2$
Carbon dioxide	CO_2	Sodium chloride	NaCl
Methane	CH_4	Calcium carbonate	$CaCO_3$
Water	H_2O	Copper carbonate	$CuCO_3$
Hydrochloric acid	HCl	Sodium carbonate	Na_2CO_3
Sulphuric acid	H_2SO_4	Potassium nitrate	KNO_3
Calcium oxide	CaO	Silver nitrate	$AgNO_3$
Iron oxide	Fe_2O_3	Barium sulphate	$BaSO_4$
Lead oxide	PbO	Copper sulphate	$CuSO_4$
Sodium hydroxide	NaOH	Sodium sulphate	$Na2SO_4$

Appendix E: Periodic Table

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1	2											3	4	5	6	7	8
							1 **H** hydrogen 1										4 **He** helium 2
7 **Li** lithium 3	9 **Be** beryllium 4											11 **B** boron 5	12 **C** carbon 6	14 **N** nitrogen 7	16 **O** oxygen 8	19 **F** fluorine 9	20 **Ne** neon 10
23 **Na** sodium 11	24 **Mg** magnesium 12											27 **Al** aluminium 13	28 **Si** silicon 14	31 **P** phosphorus 15	32 **S** sulfur 16	35.5 **Cl** chlorine 17	40 **Ar** argon 18
39 **K** potassium 19	40 **Ca** calcium 20	45 **Sc** scandium 21	48 **Ti** titanium 22	51 **V** vanadium 23	52 **Cr** chromium 24	55 **Mn** manganese 25	56 **Fe** iron 26	59 **Co** cobalt 27	59 **Ni** nickel 28	63.5 **Cu** copper 29	65 **Zn** zinc 30	70 **Ga** gallium 31	73 **Ge** germanium 32	75 **As** arsenic 33	79 **Se** selenium 34	80 **Br** bromine 35	84 **Kr** krypton 36
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[98] **Tc** technetium 43	101 **Ru** ruthenium 44	103 **Rh** rhodium 45	106 **Pd** palladium 46	108 **Ag** silver 47	112 **Cd** cadmium 48	115 **In** indium 49	119 **Sb** tin 50	122 **Sb** antimony 51	128 **Te** tellurium 52	127 **I** iodine 53	131 **Xe** xenon 54
133 **Cs** caesium 55	137 **Ba** barium 56	139 **La*** lanthanum 57	178 **Hf** hafnium 72	181 **Ta** tantalum 73	184 **W** tungsten 74	186 **Re** rhenium 75	190 **Os** osmium 76	192 **Ir** iridium 77	195 **Pt** platinum 78	197 **Au** gold 79	201 **Hg** mercury 80	204 **Tl** thallium 81	207 **Pb** lead 82	209 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

*The Lanthanides (atomic numbers 58-71) and the Actinides (atomic numbers 90-103) have been omitted
Cu and Cl have not been rounded to the nearest whole number