Applied AS/A Level GCE

Teachers Handbook

GCE in Applied Science

OCR Advanced Subsidiary GCE in Applied Science H175

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

OCR Advanced GCE in Applied Science H575

OCR Advanced GCE in Applied Science (Double Award) H775

This handbook is designed to accompany the revised OCR GCE in Applied Science specification.

Contents

Introduction

These specifications are designed to provide candidates with an introduction to Applied Science.

These specifications are set out in the form of units. Each teaching unit is assessed by its associated unit of assessment. Guidance notes are provided with these specifications to assist teachers in understanding the detail necessary for each unit.

It is important to make the point that the Teacher Support plays a secondary role to the Specification itself. The Specification is the document on which assessment is based and specifies what content and skills need to be covered in delivering the course. At all times, therefore, this Teacher Support should be read in conjunction with the Specification. If clarification on a particular point is sought then that clarification should be found in the Specification itself.

OCR recognises that the teaching of this qualification will vary greatly from school to school and from teacher to teacher. With that in mind, this Teacher Guide/Notes for Guidance is offered as guidance but will be subject to modifications by the individual teacher.

Unit G620: Science at Work

Guidance on Delivery

The intention is that this unit will provide candidates with an introduction to the importance of how science impacts on the society in which they live. It has been designed to focus on important aspects of science used in the work place. Sub-section 3.1.2 (*Organisations using science*) will allow candidates the opportunity to find out more about the organisations that employ scientists, and the involvement of science in these organisations, to enable them to understand the significance of the work they are studying. The success of parts of this unit will depend upon the availability of (potentially sensitive) data from organisations. If candidates find difficulty in obtaining suitable information, case-study material can be used. This unit should also help candidates see the relationship between what they learn, and what they may experience in a working environment. The importance of health and safety, both in a working and educational environment is introduced to support both the practical work and the way in which organisations may impact upon society and the environment. Finally, this leads onto sub-section 3.1.3 (*Science and the community*).

Sub-section 3.1.4 (*Practical techniques and procedures*) gives candidates the opportunity to carry out experimental work within a vocational context, which hopefully will relate to the work in the organisations they are researching. This practical work also gives an opportunity to put into practice risk assessment and some of the health and safety laws and regulations they have researched. In some circumstances, it may be difficult to transfer practical procedures from industry to the classroom. In these cases, it would be advisable to have some practicals available, pitched to the ability of candidates. The use of ICT plays an important role in practical procedures and, hopefully, candidates will be able to incorporate the use of dataloggers, or appropriate software packages, into their practical work.

Examples of some experimental work might be:

- titrations for acid/base calculations;
- testing quality of products (quality assurance);
- biological action of enzymes;
- food testing procedures;
- material testing techniques;
- microscopy;
- ophthalmic work;

This unit does offer the opportunity to introduce a period of appropriate work experience, if so required. This will then allow candidates to draw on their own experiences, to find out about individual organisations, and to illustrate and display knowledge and understanding that they obtained during their involvement in their individual research.

Guidance on Assessment

Candidates need to carry out research for this unit; they need to be taught how to find and select the relevant correct information and be aware of the various types of material available. Candidates need to demonstrate analysis and evaluation and will need to be taught these skills if they are to achieve the higher marks.

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

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

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

You need to mark each portfolio according to the assessment objectives and content requirements in the Assessment Evidence Grid (Appendix B).

The information on this grid will eventually be transferred onto a Unit Recording Sheet to be attached to the front of each candidate's piece of work at the point when the work is submitted for moderation. A Coursework Administration Pack will be supplied, containing all relevant Unit Recording Sheets. Where marking for this unit has been carried out by more than one teacher in a centre, there must be a process of internal standardisation carried out to ensure that there is a consistent application of the criteria as laid down in the Assessment Evidence Grids.

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

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

You use your professional judgement to determine which descriptor in a strand best suits the individual candidate's work and from the range of marks available within that particular mark band, you circle the mark that best fits the work. You then record this mark (or sum of marks if there is more than one row for that particular assessment objective) in the column headed Mark.

You need to use the full range of marks available to you. You need to award full marks in any strand for work which fully meets the criteria. This is work which is the best one could expect from candidates working at AS level.

Only one mark per AO strand will be entered (although this may be the sum from several rows – one mark per row – for that particular AO strand). The final mark for the candidate is out of a total of 50 and is found by totalling the marks for each AO strand.

The further guidance below amplifies the criteria in the *Assessment Evidence Grid* and will help the candidate to determine the appropriate mark to be awarded for each strand.

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO1	**1**	• Candidate produces a leaflet, information package or basic information on a survey carried out for **four** science-based organisations; • examples of the types of organisations to be covered are listed in sub-section 3.1.2 *Organisations using science*; in the **four** organisations, candidates include at least **one** of each type (service provider and production); • the information includes basic information on all the bullet points listed in the specification – some omissions are acceptable for this level – each candidate completes his/her own piece of assessment evidence but the research work can be a team effort; evidence of how material was selected is shown; • candidate carries out an in-depth study of **one** chosen organisation to include bullet points in the final part of sub-section 3.1.2 *Organisations using science*; some omissions are acceptable for this level; • candidate learns about the importance of health and safety in the work place and in the laboratory and selects provided information on health and safety laws and regulations and relates these to their survey and the in-depth study of **one** organisation; work is also done on risk assessments and links made to both the workplace situations and laboratory practical work; • at this level a basic coverage of the health and safety laws and regulations listed in sub-section 3.1.1 *The importance of health and safety* – could alternatively be answers to questions from worksheet(s) or a basic report, summary or leaflet (in addition, basic information on risks, hazards and risk assessments are included); • some scientific terminology has been used and candidate should have attempted some individual research; they also select and present information; spelling, punctuation and grammar should be checked;

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
	2	• candidate produces a leaflet, information package or information on a researched survey carried out for **four** science-based organisations; • evidence shows relevant information has been selected and work is clearly presented; • examples of the types of organisations to be covered are listed in sub-section 3.1.2 *Organisations using science* – the information includes some detailed information on all the bullet points listed in the specifications for the **four** organisations; candidate includes at least **one** of each type (service provider and production); • although the visits show teamwork, each candidate completes his/her own piece of assessment evidence and shows evidence of individual research; • candidate carries out a detailed case study of **one** chosen organisation to include all bullet points in the final part of sub-section 3.1.2 *Organisations using science*; information presented shows competent use of researched information; • candidate presents work which shows a detailed understanding of the health and safety laws and regulations listed in sub-section 3.1.1 *The importance of health and safety* – information is appropriately linked to the survey and their in-depth study; • in addition, information on the risks, hazards and risk assessments shows links to an industrial/service provider and to laboratory work (as detailed in the specifications); • this evidence has few omissions or inaccuracies, though some areas may not be as extensively covered as others; • scientific terminology has been used and they have individually researched, selected and presented information; spelling, punctuation and grammar should be checked and corrected where appropriate;

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO1	**3**	• candidate produces a leaflet, information package or detailed information on a thoroughly researched survey carried out for **four** science-based organisations; • evidence shows that a variety of sources have been used and relevant information has been selected and work is clearly and logically presented – examples of the types of organisations to be covered are listed in sub-section 3.1.2 *Organisations using science* – the information includes detailed and logical information on all the bullet points listed in the specifications for **four** organisations; • although the visits can still show teamwork, each candidate completes their own piece of assessment evidence and shows evidence of individual and thorough research with some evaluation and justification; • candidate carries out a comprehensive and thoroughly researched case study of a chosen organisation to include all bullet points in the final part of sub-section 3.1.2 *Organisations using science*; • candidate shows a comprehensive knowledge and understanding of the health and safety laws and regulations listed in sub-section 3.1.1 *The importance of health and safety* – work shows how the health and safety information is linked to organisation(s) and how they comply with the legislation; • in addition, candidate includes detailed information on risks, hazards and how risk assessments are implemented and linked to legislation, in the appropriate organisation; • this evidence shows a clear indication of systematic research, clear and logical presentation of work and correct and accurate use of scientific terminology and accurate use of spelling, punctuation and grammar; • there is adequate evaluation and justification of the research used.

<table>
<tr><th colspan="3">Amplification of Criteria</th></tr>
<tr><th>AO</th><th>Mark Band</th><th>Characteristics of the work one may expect to see at this mark band can be summarised as follows:</th></tr>
<tr><td rowspan="3">AO2</td><td>1</td><td>• Candidate describes, within their report, the impact on society of their one chosen organisation – information to be included is listed in sub-section 3.1.3 Science and the community – not all aspects or details are covered;
• research work which describes, and shows some understanding of the impact on society of their one chosen organisation;
• information lacks detail, with some omissions;
• in addition, evidence to show competence in completion of some straightforward calculations (see Appendix C) – this can be in the form of set worksheets, appropriately linked to work studied, or calculations based on results from one practical carried out by the candidate;
• explanations may be simplistic or contain some inaccuracies, the evidence may not be well structured or logical in presentation;
• there is evidence that a number of straightforward calculations have been completed, generally obtaining the correct solutions;</td></tr>
<tr><td>2</td><td>• candidate identifies and describes, within their report, the impact on society of their one chosen organisation – information to be included is listed in sub-section 3.1.3 Science and the community – most aspects or details are covered;
• research work which describes, and shows understanding of, the impact on society of their one chosen organisation;
• in addition, evidence to show competence in the successful completion of a number of straightforward and complex calculations (see Appendix C) – this can be in the form of worksheets, appropriately linked to work studied; calculations based on results obtained from at least one practical carried out by the candidate;
• the explanations are clear and there are few or no inaccuracies;
• there is evidence of logical presentation and structure to the work;
• there is evidence that a number of straightforward calculations have been completed obtaining the correct solutions;</td></tr>
<tr><td>3</td><td>• candidate identifies and explains, within their report, the impact on society of their one chosen organisation – information to be included is listed in sub-section 3.1.3 Science and the community – all aspects and details are covered;
• work presented is comprehensive and thoroughly researched and includes all bullet points in sub-section 3.1.3 Science and the community;
• in addition, evidence to show competence in the successful completion to the appropriate degree of accuracy of a range of calculations (more complex calculations are included – not an increase in the number from mark bands 1 and 2) – this can be in the form of worksheets or using results of their practical work;
• the material is well organised and information is presented in a clear, logical form;
• evidence that a range of calculations have been completed to the appropriate degree of accuracy, obtaining the correct solutions.</td></tr>
</table>

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO3	**1**	• A record of the safe completion of **two** practical tasks, which includes coverage of most of the bullet points from sub-section 3.1.4 *Practical techniques and procedures* – **one** can be a basic set practical exercise with some link to a vocational context, with direct instructions on what to do, and the second with less guidance and a possible link to the research work the candidate has completed; • in both practical tasks, candidate has used risk assessments, followed given instructions and used given equipment; • candidate has, with guidance, made and recorded relevant observations and/or measurements, processed some results and provided some interpretation of their results;
	2	• a record of the safe completion of **two** different types of practical tasks, which includes detailed coverage of all the bullet points from sub-section 3.1.4 *Practical techniques and procedures* for both practical tasks – **one** can be a set practical exercise with some link to a vocational context and the second linked to the research work the candidate has completed; • in both practical tasks, candidate has developed and used risk assessments and a range of techniques and equipment; • they have made and recorded relevant observations and/or measurements and processed them accurately; • they have interpreted the results, drawn any conclusions and discussed their significance, where appropriate;
	3	• a record of the safe completion of at least **two** different types of practical tasks, which includes high quality coverage of all the bullet points from sub-section 3.1.4 *Practical techniques and procedures* for both practical tasks – **one** can be a set practical exercise linked to a vocational context, the second linked to the research work the candidate has completed; • in both practical tasks, candidate has produced and used risk assessments and a range of techniques and equipment to the appropriate degree of accuracy; • they have made and recorded all relevant observations and/or measurements to the appropriate precision and processed them accurately; • they have interpreted the results, drawn conclusions and evaluated where appropriate.

Resources

Organisations

Department for Business, Enterprise & Regulatory Reform,
1 Victoria Street, London, SW1H 0ET
www.berr.gov.uk

Natural Environment Research Council
Polaris House, North Star Ave., Wiltshire SN2 1EU
www.nerc.ac.uk

Office for National Statistics
1 Drummond Gate, London SW1V 2QQ
www.statistics.gov.uk

Royal Society of Chemistry
Burlington House, Piccadilly, London W1V 0BN
www.rsc.org

Soap and Detergent Industry Association
3/5 Clair Road, West Sussex RH16 3PP
www.chemsoc.org

Publications

Connexions Service - www.connexions.gov.uk
Leaflets from National Health Service
Leaflets from main utilities – gas, water, electricity (available locally).
It is advisable to form a collection of suitable leaflets, brochures etc., from careers areas at schools and colleges.

Textbooks

	GNVQ Science Advanced Nuffield Science in Practice	Heinemann	043 563 2531
Gadd K & Holman J (eds)	*Advanced Science*	Nelson	017 448 2353

(Both books are based on old specifications, but content is still useful).

David Ballard *et al.*	*OCR A Level Applied Science*	Heinemann	978 0435692 12 4

Unit G621: Analysis at Work

Guidance on Delivery

The intention is that this unit will provide candidates with an introduction to the importance of testing and analysis within many industries and work places. It begins by focusing on the more obvious methods of testing, and then considers the importance of analysing procedures for quality control and improving efficiency.

This unit should also help candidates learn how to do simple tests in the laboratory and to be able to link them to realistic testing methods within one of the industries they have been researching. From there, they can be led into less overt testing methods which relate to the monitoring of standards. Quality control is a major consideration for a lot of businesses and many will spend a lot of money to analyse their output.

Another expenditure might be considering ways in which to improve productivity or efficiency. When investigating efficiency, it should be natural for candidates to start discussing energy in terms of flow and changes, saving energy and the sources of energy. This helps link back to the environmental concepts of G620: Science at work, and encourages them to look at how their industries are contributing to the global situation.

Throughout this unit, candidates need to be given the opportunity to carry out experimental work within a vocational context, which hopefully will relate to the work in the organisations they have researched. This practical work also gives an opportunity to put into practice risk assessment and some of the health and safety laws and regulations they have studied in Unit G620: Science at work. It is suggested that a specific assessment session be provided for the purpose of the practical assessment AO3. Candidates then have the opportunity to try and learn about all the different tests before being tested. For more able candidates, you may wish to assess using ‘unknown’ substances for candidates to discover and draw conclusions from.

Qualitative analysis

This allows candidates to build on their skills, knowledge and understanding from GCSE Science or Applied Science with specific regard to simple test-tube reactions for the anions and cations listed.

Many of the cations can be identified by their reactions with aqueous sodium hydroxide and/or aqueous ammonia. Metal ions from Groups 1 and 2 can be identified by flame tests. The usual test for the ammonium ion is to heat its aqueous solution with an alkali and to detect the ammonia gas evolved.

Qualitative tests for the anions are a continuation of GCSE work. It is recommended that an aqueous nitrate is identified by gently heating it with aluminium powder and aqueous sodium hydroxide and identifying the ammonia gas evolved. The traditional ‘brown ring’ test, with its use of concentrated sulfuric acid, is less safe for use by candidates.

A primary alcohol can be identified by the colour change which occurs when it is oxidised on warming with acidified potassium dichromate (VI) or potassium manganate (VII) solutions.

Aldehydes and ketones may be identified by the coloured precipitates given with the 2,4-dinitrophenylhydrazine reagent. A distinguishing test for an aldehyde might use Benedict's, Fehling's or Tollens' reagents.

Carboxylic acids can be identified using any of the characteristic reactions given by acids.

Centres may not have the use of an infrared spectrometer but primary alcohols, aldehydes and carboxylic acids can be identified by looking for the presence or absence of frequencies corresponding to the -OH and C=O groups and most text books of AS standard will give diagrams showing the required spectra.

Although candidates need to be aware of the applications of gas-liquid chromatography and HPLC in industry, it is expected that laboratory work will concentrate on separations using thin-layer and/or paper chromatography.

Suitable exercises might include the separation and identification of common analgesics using TLC and the separation of metal cations using paper chromatography. Exercises need to be linked to industrial needs as far as possible.

Quantitative analysis

Candidates need to have experience of simple titrations that involve making and using standard solutions. They should have carried out straightforward acid-base, redox titrations.

The titrations performed should have a vocational slant. Suggested exercises include finding the:

- concentration of commercial vinegars;
- % of iron in 'iron tablets';
- % of copper in brass samples;
- hardness of water using a solution of EDTA.

Candidates need to be aware of the principles behind colorimetry and to have tried a colorimetric procedure. This might be to find the percentage of copper in a sample of brass, or to determine the percentage of iron in samples of iron filings.

They need to be aware of the great importance of colorimetric techniques in industry and in hospital laboratories.

Details of these procedures may be found in books of qualitative and quantitative analysis, and the *Sigma* catalogue from the *Aldrich* company lists reagents and some details for aspects of colorimetry in hospital laboratories.

Candidates need to be aware that much of the routine analysis in industrial and medical laboratories is automated and computer-linked. This can be discussed when comparing industrial applications with their own analytical work.

Energy & Efficiency

Candidates will be aware of exothermic and endothermic processes from previous work and this can be extended to show why the burning of fuels is a net exothermic process.

Practical work on enthalpy of combustion of various fuels can be used as investigative work.

Candidates should be aware of small-scale electricity generation by renewable sources, e.g. by using wind or solar power, and be able to compare the benefits and problems of large- and small-scale generation in a simple quantitative way.

There is much interest in the efficiency of power-generation processes and candidates should be aware of the meaning of the term efficiency and realise that many electrical-generation processes are not highly efficient in terms of the useful energy produced.

It is of great interest to consumers to have their heat and power systems as efficient as possible.

Candidates need to produce a report from information gathered from a non-domestic consumer that outlines their energy policy and include some detail about how this consumer uses their energy as efficiently as possible.

It is not intended that this report should be very detailed; indeed many companies may be reluctant to provide specific, detailed information. Smaller companies and local educational establishments may be a useful source of information for this sub-section. If candidates find difficulty in obtaining this information, case study material can be used.

Many companies are, however, very willing to disclose information about the environmental impacts of their work and the impact the company has on the local economy, and this information should form part of the report outlined above.

Guidance on Assessment

Candidates need to carry out a great deal of research for this unit; they need to be taught how to find and select the relevant correct information and be aware of the various types of material available. Candidates need to demonstrate analysis and evaluation and will need to be taught these skills if they are to achieve the higher marks.

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

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

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

You need to mark each portfolio according to the assessment objectives and content requirements in the *Assessment Evidence Grid* (Appendix B).

The information on this *grid* will eventually be transferred onto a *Unit Recording Sheet* to be attached to the front of each candidate's piece of work at the point when the work is submitted for moderation. A *Coursework Administration Pack* will be supplied, containing all relevant *Unit Recording Sheets*. Where marking for this unit has been carried out by more than **one** teacher in a centre, there must be a process of internal standardisation carried out to ensure that there is a consistent application of the criteria as laid down in the *Assessment Evidence Grids*.

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

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

You use your professional judgement to determine which descriptor in a strand best suits the individual candidate's work and from the range of marks available within that particular mark band, you circle the mark that best fits the work. You then record this mark (or sum of marks if there is more than **one** row for that particular assessment objective) in the column headed *Mark*.

You need to use the full range of marks available to you. You need to award full marks in any strand for work which fully meets the criteria. This is work which is the best one could expect from candidates working at AS level.

Only **one** mark per AO strand will be entered (although this may be the sum from several rows – **one** mark per row – for that particular AO strand). The final mark for the candidate is out of a total of **50** and is found by totalling the marks for each AO strand.

The further guidance below amplifies the criteria in the *Assessment Evidence Grid* and will help the candidate to determine the appropriate mark to be awarded for each strand.

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO1	**1**	• Candidate produces a brief report that gives information about a non-domestic consumer of energy and brief details of their energy policy; • the report includes brief comments about how the non-domestic consumer ensures that the efficient use of energy has been considered; • the report outlines how the non-domestic consumer has considered the economic and environmental impacts of their energy policy;
	2	• candidate produces a report that gives selected information about a non-domestic consumer of energy and details of their energy policy; • the report includes comments about how the non-domestic consumer ensures that the efficient use of energy has been considered, a definition of energy efficiency should be included; • the report shows how the non-domestic consumer has considered the economic and environmental impacts of their energy policy;
	3	• candidate produces a report that gives information about a non-domestic consumer of energy and a more detailed account of their energy policy; • the report includes more detailed comments about how the non-domestic consumer ensures that the efficient use of energy has been considered, relating information to energy efficiency; • the report shows, in more detail, how the non-domestic consumer has considered the economic and environmental impacts of their energy policy.
AO2	**1**	• A report that shows energy transfer involved in the generation of electricity and a brief description of large-scale and small-scale electrical generation; • some *straightforward* calculations that use provided data on energy values (calorific values) and costs of generating electricity (one non-renewable/one renewable), with generally correct solutions;
	2	• a report, in more detail, that shows the forms of energy involved in the generation of electricity and includes a description and a comparison of the generation of electricity on large and small scales; • information on the energy, values (calorific values) and costs of different fuels/energy sources (one non-renewable/one renewable), some *straightforward* & complex calculations, with generally correct solutions;
	3	• a detailed report, that compares the relative problems and benefits of the generation of electricity on large and small scales; • a number of *straightforward* and more *complex* calculations, using researched data, on the energy values (calorific values) and costs of different fuel/energy sources (range of renewable/non renewable), with correct solutions that are given to an appropriate degree of accuracy.

AO	Mark Band	Characteristics of the work one may expect to see at this mark band can be summarised as follows:
AO3	1	• A report of a qualitative analysis carried out on a material that is linked to a vocational context – this includes a risk assessment, relevant observations and some interpretation; • a report of a quantitative analysis carried out on a material that is linked to a vocational context – this includes a risk assessment, relevant observations and calculations – the results are processed with some interpretation; • a report of an additional exercise that is linked to a vocational context – this includes a risk assessment, relevant observations and, where necessary, calculations – the results are processed with some interpretation;
	2	• a report of a qualitative analysis carried out on a material that is linked to a vocational context – this includes a more detailed risk assessment, relevant observations and a detailed interpretation of the results, and the information is presented clearly and logically; • a report of a quantitative analysis carried out on a material that is linked to a vocational context – this includes a more detailed risk assessment, relevant observations and more detailed calculations – the results are processed with detailed interpretations and the information is presented clearly and logically; • a report of an additional exercise that is linked to a vocational context – this includes a more detailed risk assessment, relevant observations and, where necessary, calculations – the results are accurately processed and interpreted and the information is presented clearly and logically;
	3	• a report of a qualitative analysis carried out on a material that is linked to a vocational context – this includes a detailed risk assessment, relevant observations and a detailed interpretation of the results and, where necessary, an evaluation – the information is presented clearly and logically; • a report of a quantitative analysis carried out on a material that is linked to a vocational context – this includes a detailed risk assessment, relevant observations and detailed calculations carried out to the correct level of accuracy – the results are processed with a detailed interpretation and evaluated – the information is presented clearly and logically; • a detailed report of an additional exercise that is linked to a vocational context – this includes a detailed risk assessment, relevant observations and detailed calculations – the results are processed with a detailed interpretation of the results and evaluated, and the information is presented clearly and logically.

Resources

Organisations

The Centre for Alternative Technology
Machynlleth, Powys, Mid Wales, SY20 9AZ
www.cat.org.uk

Chemical Industry Education Centre
York University, York, YO10 5DD
www.uyseg.org/ciec_home.htm

Textbooks

David Ballard *et al.*	*OCR A Level Applied Science*	Heinemann	978 0435692 12 4
Vogel	*Vogel's Textbook of Quantitative Chemical Analysis*	Longman	058 244 693 7
	Modern Chemical Techniques	The Royal Society of Chemistry	187 034 319 0

Websites

Electrical generation and supply companies:

www.eonenergy.com
www.scottishpower.co.uk
www.swalec.co.uk
www.southern-electric.co.uk
www.edfenergy.com

The Institute of Physics - www.iop.org

The Royal Society of Chemistry - www.rsc.org

Unit G622: Monitoring the Activity of the Human Body

Guidance on Delivery

Respiration in energy terms

Candidates may well have met the basic biology involved in this section in their science studies at Key Stage 4. They are not expected to give detailed descriptions of the chemistry involved in aerobic and anaerobic respiration. However, they need to understand enough about the processes to say how they differ. Candidates need to relate changes in heart rate and depth and frequency of ventilation to changes taking place at a cellular level in the muscle during various levels of physical activity.

Structure and function of the circulatory and respiratory systems

Once more, many candidates will have an adequate grounding in this area from their Key Stage 4 Science. They may well benefit from reviewing their knowledge about the mammalian cardiovascular and lung system. Candidates might be encouraged to dissect a sheep's or pig's heart and lungs to gain a fuller understanding of the **two** major organ systems involved in this section. This activity could also provide an opportunity to discuss any ethical issues arising from dissection, transplant surgery in general, use of a pig's heart in transgenic transplant surgery etc. It might also provide an opportunity for candidates to do a risk assessment for the dissection/surgery.

As far as written assessment is concerned, candidates will be expected to relate data obtained by monitoring to what must have been going on at an organ level in the patient providing the data. They need to identify structures and processes correctly so they can, for example, relate what an ECG trace shows about the rate and rhythm of the heart to the structures of the heart, or account for a rise in blood pressure.

Uses of physiological measurements

Candidates are likely to find different 'normal' values and ranges quoted in different sources and values given in 'non-standard' units.

For the purposes of assessment, values quoted in the specification will be used as normal values in the resting state.

Methods of taking physiological measurements

Candidates need to analyse data they have obtained from their own measurements and data from secondary sources. Many of the monitoring devices involved in this unit are sophisticated, expensive and not readily accessible to candidates. However, where possible, they should be provided with the opportunity to use monitoring equipment.

Difficulties associated with collecting data from people are recognised, but at this level of study, candidates need to collect data that is relevant, sufficient and reliable. When measuring physiological status, they will need to choose their subjects carefully and agree what they can monitor, over what time scale, and at what intervals. It would be useful if the group as a whole covered a wide range of individuals to get a spread of results and a sufficiently large enough sample to show the range of variation.

If it is possible to collect data from people who have to manage particular conditions (for example asthma or diabetes), this would add interest and meaning to the study. If not, candidates should make comparisons with published data.

They could use a spirometer to measure tidal volume and vital capacity and take measurements using a peak flow meter, obtaining more detailed ventilation performance data from secondary sources.

If they use a manual sphygmomanometer they must be supervised.

Imaging methods

X-rays

- Place of X-rays in the electromagnetic spectrum.
- Qualitative – relative penetration for different atomic masses.

CAT scans

- Advantage of 3D image
- Diagram of rotating source
- Idea that computer is used to convert the image

MRI

- Detects hydrogen, and hence water, in cells
- Strong magnetic field needed – obtainable by using superconducting magnet
- Radiation causes oscillation in nucleus
- Excited nuclei re-radiate signalling their positions
- Detector picks up radiation emitted by nucleii

Ultra sound

- Frequencies used compared with normal range of hearing
- Reflection at interfaces between layers
- Need for gel between probe and skin so that signal not reflected at skin surface

A visit to a hospital would complement work on secondary sources.

Regulations governing specific procedures and data management

Any practical work undertaken during the course will provide opportunities for much of the work in this section. Candidates also need to be made aware of the question of reliability when considering secondary sources of data.

Ethical issues related to monitoring, diagnosis and treatment

This unit focuses on the way in which very personal data can be obtained and used. Therefore it is likely that numerous opportunities for candidates to consider ethical issues will arise as they progress through the unit.

Candidates need to be aware of the risks associated with imaging techniques. They could consider, for example, the potential effect of X-ray radiography on the fertility of a patient balanced against the possible benefits. This topic could also lead to discussion of the health and safety implications of working in a radiography department from a technician's point of view.

Guidance on Assessment

This unit is assessed through a 1½ hour question paper with **90** marks which assesses AO1 (**64** %) and AO2 (**36** %).

Resources

Publications

Biological Sciences Review
New Scientist
Scientific American

Good references to ethical issues can be found in SATIS units:

What is Science?	086 357 158 1
What is Technology?	086 357 159 X
How Does Society Decide?	086 357 160 3

Textbooks

Standard Advanced Level Biology/Human Biology texts on the market have good general material on monitoring the activity of the human body.

Ballard *et al.*	*OCR A Level Applied Science*	Heinemann	978 0435692 12 4
Howley ET & Franks BD	*Health Fitness Instructor's Handbook*	Human Kinetics	0 873 229 584X
McArdle WD Katch FI & Katch VL	*Essentials of Exercise Physiology*	Lippincott Williams & Wilkins	0 683 305 077X
Powers SK & Howley ET	*Exercise Physiology*	McGraw-Hill Higher Education	0 071 180 850X
Wilmore JH & Costill D	*Physiology of Sport and Exercise*	Human Kinetics	0 736 000 844X

Websites

www.asthma-help.co.uk
www.asthma.org.uk
www.bescenta.co.uk
www.bhf.org.uk
www.brit-thoracic.org.uk
www.chemsoc.org
www.concept2.co.uk
www.doh.gov.uk
www.ecglibrary.com
www.food.gov.uk
www.lunguk.org
www.medicinenet.com
www.netdoctor.co.uk
www.polar-uk.com
www.powerjog.co.uk
www.pponline.co.uk
www.rsc.org
www.statistics.gov.uk
www.studentbmj.com
www.who.int
www.winhealth.co.uk

Unit G623: Cells and Molecules

Guidance on Delivery

This unit needs to draw on the scientific knowledge, skills and understanding provided by study of Units G620, G621 and G622. It should also be possible to carry out the unit early in the course, allowing the development of basic biological skills in a context which builds on work done in GCSE Science or Applied Science.

Laboratory practical work, and the development of practical skills, is an integral part of the unit (it needs to constitute around 40-50% of the time allocated). The laboratory work can be completed at any time of the year, as the material required is not season-specific.

The principle aim of the unit is to give candidates a sufficient grounding in theoretical and practical cell biology to allow them to appraise critically the work and moral issues confronting them, and to review how these problems might be addressed by professional biologists and society as a whole.

Numerous opportunities for candidates to consider ethical issues will arise as they progress through the unit and in particular in sub-section 3.4.5 *Investigation of the work of molecular biologists in cellular research*. Examples of issues worth considering might include:

- the possibility of error arising during diagnostic testing;
- human-rights issues where genetic information might be used, for example, to block applications for employment, insurance or mortgage facilities;
- prenatal screening in order to detect genetic disorder and the subsequent decision whether or not to pursue a selective abortion;
- how serious a defect has to be before a selective abortion might be considered;
- the cost-effectiveness of screening.

Guidance on Assessment

As well as knowledge and understanding, candidates will be assessed on their ability to plan, observe, analyse and evaluate, and will need to be taught these skills if they are to achieve the higher grades.

AO1 and AO2 will be assessed by a **45** minute theory paper of **45** marks. These marks are weighted so that the paper is worth **50%** of this unit.

AO3 will be assessed by a pre-prepared plan for an investigation. Candidates will **not** be expected to carry out their plan. The nature of the investigation will be specified by OCR and should be presented to candidates **six** weeks before the external examination. Candidates will hand in the plan on a date specified by you which will be not later than the date of the examination. The marks for the plan will be weighted so that the plan is worth **50%** of this unit.

The plan will be marked by OCR using the following criteria:

Candidates:	Marking criteria	Mark
• include a risk assessment to show how the investigation will be carried out safely;	easily recognised safety procedures highlighted;	**1**
• make a prediction and produce justification;	prediction made; with justification;	**1** **1**
• describe and explain the reasoning behind any preliminary work carried out;	description; clear and in detail; reasons explained; clear and in detail;	**1** **1** **1** **1**
• identify relevant secondary sources of information used;	identified; relevance explained;	**1** **1**
• plan how to use appropriate techniques to carry out a detailed practical investigation;	basic skills and reasonable accuracy; sound skills and accuracy;	**1** **1**
• list the equipment required;	range of appropriate; full range of appropriate;	**1** **1**
• state the number of measurements to be undertaken;	appropriate number;	**1**
• state the range of measurements to be undertaken;	need recognised; appropriate range;	**1** **1**
• identify any variables that could affect the validity of any conclusions made and explain how variables will be controlled;	relevant variables are identified; controlled;	**1** **1**
• show how they would present and display the data they could collect using suitable methods;	suitable methods identified;	**1** **1**
• indicate how the data will be analysed;	simple data-handling; conclusions possible;	**1** **1**
• evaluate the investigation.	recognises sources of error; suggests methods for improving accuracy and/or validity.	**1** **1**
	Total marks available:	**24**
	Additional marks awarded on plan for use of scientific terminology:	**1**
	Total:	**25**

Resources

Organisations

Advisory Committee of Genetic Modification (ACGM)
Advisory Committee on Genetic Testing (ACGT)
Advisory Group on Scientific Advances in Genetics (AGSAG)
Cystic Fibrosis Foundation (CFF)
Gene Therapy Advisory Committee (GTAC)
Human Fertilisation and Embryology Authority (HFEA)
Human Genetics Advisory Commission (HGAC)
National Institute for Clinical Excellence (NICE)

Publications

New Scientist
Scientific American

Textbooks

Ballard D *et al.*	*OCR A Level Applied Science*	Heinemann	978 0435692 12 4

Websites

www.cancerbacup.org.uk
www.cff.org
www.advisorybodies.doh.gov.uk/genetics/acgt
www.advisorybodies.doh.gov.uk/genetics/gtac
www.advisorybodies.doh.gov.uk/hgac/index.html
www.hfea.gov.uk
www.hse.gov.uk
www.ost.gov.uk
www.nice.org.uk

Unit G624: Chemicals for a Purpose

Guidance on Delivery

This unit needs to draw on the scientific knowledge, skills and understanding provided by study of G620: *Science at work*, G621: *Analysis at work* and G622: *Monitoring the activity of the human body*. The unit revisits some previous learning about ionic and covalent bonding and structure that candidates have met in Key Stage 4 Science or GCSE Applied Science. For some candidates, these areas will need revisiting and reinforcing, before they meet the new ideas in this unit.

The principal aim of this unit is for candidates to understand the extent and importance of the chemical industry in producing chemicals to make industrial and consumer goods. They need to think about the roles for chemists in the industry, including chemical engineers. Candidates, wherever possible, need to refer to information from everyday sources, e.g. labels, advertisements, magazine articles and websites, to find examples of chemical products to illustrate their work.

The importance of the work of the synthetic chemist and quality-control chemist is a key part of the chemical industry. Candidates will be carrying out a laboratory synthesis, where they will need to think about issues relating to the nature of a laboratory chemist's work.

Throughout the unit, candidates need to be encouraged to carry out their own research into the processes that they are studying, and think about issues such as the importance of the products, the sustainability of the processes used and the concerns about the use of energy.

Organics and Inorganics

This allows candidates to build on their skills, knowledge and understanding from GCSE Science and Applied Science, with specific regard to their work on formulae, equations and bonding.

Most GCE Chemistry textbooks contain sections that can be used in the teaching of structural formulae. Practical work can be carried out to compare ionic and covalent compounds. Research into data about properties of each can compare, for example, melting points, appearance, and uses.

To follow a vocational approach, candidates can analyse labels from, for example, cosmetics, medicines, fertilisers and washing powders, to find examples of organic and inorganic products. They need to look up data for a range of the compounds they study using either standard GCE data books or on-line data sources (see Resources). Candidates may process this data using graphs, spreadsheets etc. Below are mentioned some software packages, e.g. ISIS/DRAW, which can be used to draw structural formulae and be imported into word-processed documents. References, such as *The Essential Chemical Industry*, provide information on the main products of the U.K. industry.

The chemistry of oil products

This section builds on work at KS4 or GCSE Applied Science relating to polymers and chemicals from salt, and also links directly with the recognition of structural formulae in sub-section 3.5.1 *Organic and inorganic compounds*.

Candidates need to become familiar with the structural formulae of the main organic products from oil. They need to recognise the formulae of all the compounds stated in sub-section 3.5.1 *Organic and inorganic compounds* and also esters, polyesters, polymers.

Candidates need to understand that chemical consumer products are usually a mixture of compounds, often both organic and inorganic, each with different properties, e.g. each additive listed in washing powder has a different purpose.

Polymers need to be represented via structural formulae, as both monomers and polymers. Examples need to be limited to poly(ethene) type polymerisations, with a change in the side group to produce polymers such as PTFE and poly(phenylethene) (polystryene). In the study of polymers, candidates need to link the structure of the polymer to its properties and uses, e.g. how the presence of large groups or side groups stop chains moving and cause rigidity, brittleness and higher melting points.

Candidates can carry out some investigative work by:

- researching the structural formulae of some polymers;
- finding out about their properties and linking this to their structure.

Candidates need to discuss the properties of polymers such as melting point, flexibility and strength by using ideas about the structure and layout of the chains.

Manufacturing processes

This section builds on work at GCSE Additional and Core Science or Applied Science. Candidates need to be familiar with the idea that oil is extracted and separated into useful fractions by fractional distillation. There are videos available (see below) to recap these ideas.

Candidates need to understand that the fractions from crude oil undergo a series of chemical reactions and processing in the refinery to produce useful products and to ensure that supply meets demand for the lighter oil fractions. They need to appreciate the need for this, in terms of the economic profitability of the process, and the environmental desirability of the maximum use being made of the crude oil resource with the minimum waste produced.

The study of petrol is a useful context for studying reforming. Candidates can research the changes in the composition of petrol since the banning of lead compounds, and the role of reforming in increasing the octane rating of petrol-based fuels. They need to recognise reforming reactions by looking at the structures of the reactants and products.

Catalysts need to be discussed in terms of increasing rates of reaction and lowering the energy demand of processes. Important areas to discuss include:

- examples of catalysts linked to processes;
- the role of lowering activation energy (this can be represented graphically);
- a model of the surface action of heterogeneous catalysts;
- the difficulties caused by catalyst poisoning of heterogeneous catalysts and the importance of catalyst regeneration;
- examples of the use of homogenous catalysts, e.g. acid catalysts used in esterification (this links to the preparation of a product, see below);
- the process difficulties of separating a homogeneous catalyst from the mixture of products;
- the long-term economic benefit of reduced process cost vs high initial investment to buy the catalyst.

Practical work to illustrate catalysis could be carried out, e.g. testing the effectiveness of different metal oxides in catalysing the break down of hydrogen peroxide.

Candidates need to look at specific catalysts used in addition polymerisation, e.g. how the discovery and use of Zeigler catalysts revolutionised the polyethene industry.

Candidates need to evaluate chemical processes by looking at simple flow charts and discussing the broader implications of the process, for example:

- whether the process uses non-renewable raw materials;
- whether it is possible to use other, renewable, raw materials;
- the energy that is used;
- how the process is adapted to reduce energy demand;
- the waste products that are produced and whether they are environmentally damaging;
- what health and safety issues there are for people working on the process;
- the by-products that are made and whether they can be used;
- the importance of the products and for what they are used.

Examples of processes that can be used for teaching purposes include the membrane cell for the electrolysis of brine, the Haber process for the manufacture of ammonia and the Contact process for the manufacture of sulfuric acid. Candidates need to realise that the idea of the chemical industry as being a producer of both water- and air-pollutants is outdated, and that chemical technology is at the forefront of the ‘search for solutions’ in terms of environmental impact of manufacturing processes. When considering processes involving petrochemicals, candidates need to be aware of the conflicting demand for oil for immediate use as a fuel and for long-term use as a chemical feedstock.

Preparing and analysing a chemical product

Candidates who have followed the GCSE Applied Science course will have experience of calculating percentage yields. Many candidates will find the mathematics challenging and will need support.

Candidates need to prepare a sample of two products. They need to discuss and consider issues of how their method can be adapted to maximise the yield they produce. They need to use an equation for the reaction to suggest suitable quantities to use, and make decisions about which reactant needs to be in excess to maximise yield. Their preparations need to be carried out under safe conditions according to risk assessments that they produce themselves.

Candidates need to use GCE techniques, e.g. accurate measuring of quantities using accurate balances, pipettes or burettes where appropriate. Solid products need to be purified by recrystallisation, liquids by distillation.

The final product can be tested for purity using a melting-point or boiling-point test or chromatography. Analysis of the products can include quantitative testing both inorganic and organic (Unit G621: *Analysis at work*).

Candidates need to use data from their initial weighing of reactants and the final mass of their product to show their percentage yield. They need to suggest how the yield could be improved.

Candidates need to discuss their work as an analogy of the work of synthetic chemists, who produce new molecules for testing as drugs and cosmetics. Such samples need to be of the highest purity. They also need to appreciate the role of quality control chemists who test samples of compounds and products before they are released for sale.

Suggestions for suitable products to prepare include:

- Esters of ethanoic, propanoic or butanoic acids;
- 1-bromobutane from butan-1-ol;
- Aluminium chloride;
- Boric acid;
- Ammonium chloride (a fertilizer);
- Ammonium iron (II) sulfate.

Most standard GCE textbooks give details of suitable preparations that candidates can use as a basis for their work, and give guidance to candidates about the techniques needed.

Guidance on Assessment

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

You need to mark each portfolio according to the assessment objectives and content requirements in the *Assessment Evidence Grid* (Appendix B).

The information on this *grid* will eventually be transferred onto a *Unit Recording Sheet* to be attached to the front of each candidate's piece of work at the point when the work is submitted for moderation. A *Coursework Administration Pack* will be supplied, containing all relevant *Unit Recording Sheets*. Where marking for this unit has been carried out by **more than one** teacher in a centre, there must be a process of internal standardisation carried out to ensure that there is a consistent application of the criteria as laid down in the *Assessment Evidence Grids*.

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

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

You use your professional judgement to determine which descriptor in a strand best suits the individual candidate's work and from the range of marks available within that particular mark band, you circle the mark that best fits the work. You then record this mark (or sum of marks if there is more than one row for that particular assessment objective) in the column headed *Mark*.

You need to use the full range of marks available to you. You need to award full marks in any strand for work which fully meets the criteria. This is work which is the best one could expect from candidates working at AS level.

Only **one** mark per AO strand will be entered (although this may be the sum from several rows – **one** mark per row – for that particular AO strand). The final mark for the candidate is out of a total of **50** and is found by totalling the marks for each AO strand.

The further guidance below clarifies the criteria in the *Assessment Evidence Grid* and will help the candidate to determine the appropriate mark to be awarded for each strand.

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO1	**1**	• **Four** examples of chemical compounds (**two** inorganic and **two** organic), the formulae, uses and properties of the compounds are presented clearly; • basic summary outline giving more information about two further examples; • the account includes relevant material that the candidate has covered in the lessons, but may lack depth and detail or may include irrelevant material; • spelling, punctuation and grammar to be corrected;
	2	• **four** examples of chemical compounds (**two** inorganic and **two** organic) are given and detailed, and appropriate formulae are shown, e.g. full structural, with basic information on bonding; • a sound and detailed discussion of the uses of the compounds is given; • some attempt has been made to discuss the properties of the compounds and to make links to its uses; • an account of the chemistry behind **two** compounds is presented including properties, preparation, and uses supported by relevant equations; • account to show the use of appropriate scientific language and correct punctuation and grammar;
	3	• full names and formulae are given for all examples (**two** inorganic and **two** organic), with detailed information on bonding; • some additional information is presented, sourced from independent research; • a full discussion links properties to structure and uses for two of the compounds; • a fully-researched account of the chemistry of two of the examples is given, e.g. a polymer, to link its structure at a molecular level to its properties, preparation and uses; • the discussion is of a suitable depth, with evidence of detailed research and understanding of the reactions involved; • the account to show suitable selection of researched material and correct spelling, punctuation and grammar.

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO2	**1**	• Evidence of calculating theoretical and actual yields; • one industrial chemical process is outlined at a basic level, e.g. showing the conditions, raw materials and products; • the discussion includes a list of some of the uses of the products and a mention of a catalyst; • some advantages and/or disadvantages of the process are identified;
	2	• calculations of % yields and data and calculations showing costs to produce chemicals prepared (lab or industrial); • a sound description of the process is given, with additional depth and detail including, for example, equations or flow charts where appropriate; • the role of the catalyst is discussed more fully; • a more balanced, detailed discussion about the advantages and disadvantages of the processes is included; • there is evidence of logical presentation and structure to the work;
	3	• calculations showing suitable accuracy and use of selected researched data; • a fully researched, very detailed account of the process is given, explaining all reactions fully, using a range of detailed techniques, e.g. equations, structural formulae, charts, flow diagrams; • a full account of the chemistry of catalysis is given, e.g. identifying the nature of the catalyst (hetero or homogeneous); • evaluation shows a sophisticated understanding of the potential social, economic and environmental impacts of the process.

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO3	**1**	• Evidence of completion of preparations; • workable methods have been researched and presented with safe risk assessments; • method and results are presented but may lack detail, e.g. quantities, measurement techniques and apparatus used may not be fully explained; • awareness is shown that the yield can be increased by changing the conditions;
	2	• evidence of confident completion of preparations; • more detailed methods have been researched, showing details of all apparatus and quantities used; • methods will be able to be followed fully by another candidate; • workable risk assessments are included, but this may contain irrelevant information; • observations have been recorded and presented systematically; • some processing of either the results from the preparations or the analysis; • workable suggestions about increasing the yield have been suggested;
	3	• accurate and confident completion of practical work; • very detailed methods have been researched with full descriptions of each stage of the preparation, purification and analysis of the products; • methods are very clearly presented using, for example, diagrams, numbered steps, tables or a flow chart; • full, detailed risk assessments are included showing selectivity in the information presented; • all measurements are recorded and presented systematically using a range of methods, e.g. prose, numbered lists, tables, graphs; • any anomalous observations are noticed and commented on; • data has been processed appropriately to determine a percentage yield; • methods of the preparations have been systematically evaluated and suggestions for improvements have been made.

Resources

CD-ROM

A free CD-ROM, *'The Science Behind Medicines'*, that includes a guide to drawing structural formulae is available from GlaxoSmithKline - resources@edist.co.uk, www.gsk.com

Organisations

Association for Science Education
College Lane, Hatfield, Herts, AL10 9AA
www.ase.org.uk Tel: 01707 283000

Chemical Industry Education Centre
York University, York, YO10 5DD,
www.ciec.org.uk Tel: 01904 432523

Publications

GlaxoSmithKline - www.gsk.com/education

The Essential Chemical Industry	Chemical Industry Education Centre	185 342 577 X
Water	Unilever	Educational Booklet

(both available from ASE booksales - see above)

Textbooks

Ballard D *et al.*	*OCR A Level Applied Science*	Heinemann	978 0435692 12 4
	Salters Advanced Chemistry: Chemical Ideas	Heinemann	043 563 120 9
	Salters Advanced Chemistry: Chemical Storylines	Heinemann	043 563 119 5

Websites

Esso Classroom Modules on Oil - www.esso.co.uk
GlaxoSmithKline - www.gsk.com
Oil information - www.schoolscience.co.uk

Structural formulae drawing packages (free downloads):
www.acdlabs.com/download
www.mdl.com/download/idraw.html

Websites for looking up data:
http://chemfinder.cambridgesoft.com
www.chemsoc.org/viselements
www.webelements.com

Unit G625: Forensic Science

Guidance on Delivery

This unit focuses on some of the applications of forensic science that are most likely to be of interest to candidates. Sufficient time needs to be allowed for these topics to be covered in as much depth as is appropriate at this level whilst giving a stimulating learning experience.

The emphasis of the unit is on the practical techniques used by the forensic scientist. Most of the assessed practical elements of the unit require only simple apparatus or easily obtainable chemical reagents. There are opportunities, however, to carry out more sophisticated analyses. Although there are no assessed practical elements in sub-section 3.6.1 *Recording and collection of evidence*, it is hoped that, time permitting, candidates will be given the opportunity to carry out some of these techniques to facilitate their understanding of the science involved. These, along with the practical assessment (AO3), will give opportunities to reinforce the need for quality and objectivity in forensic investigations.

The success of this unit will depend on the availability of up-to-date information and resources. There are numerous websites devoted to forensic science, including one for the Forensic Science Service (www.forensic.gov.uk) which is a good starting point. Where centres anticipate that candidates will find difficulty in locating appropriate sources, case-study material may be substituted.

Recording and collection of evidence

An overview of the reasons for preserving and recording the crime scene needs to be discussed and then candidates need to research the topic in detail. Modern methods, e.g. thermography, need to be discussed in addition to other methods, e.g. conventional photography.

Candidates need to research the wide range of techniques used to collect and visualise evidence and understand some of the science behind the methods; once again, it is essential that contemporary literature be consulted to review modern techniques. Many techniques are available and the modern forensic scientist chooses those best suited to the situation. It is hoped that candidates will be given the opportunity to try out some of the techniques. They need to be aware of at least **one** of each of the chemical, biological and physical techniques given in sub-section 3.6.1 *Recording and collection of evidence*. The wide variety of fingerprinting techniques available, for both hard and porous surfaces (see *Saferstein*, 2001), should give candidates an early opportunity to evaluate different forensic methods before producing their report in sub-section 3.6.3 *Evidence and proof*. The implementation of precautions to prevent contamination and, as a consequence, the production of a report that is admissible in court, and measures to ensure the safety of the forensic scientist, need to be highlighted.

Candidates need to be aware of the need for forensic scientists to behave ethically: not to offer opinions or conclusions which are untrue or are not supported by accepted scientific data, or to misrepresent their authority or expertise. Candidates need to be aware of, and be able to discuss, the value to the police of retaining samples and data from suspects and those convicted of crimes, the ethical considerations (particularly where there have been no convictions), the current legal framework, and the value and importance of privacy.

Analysis of evidence

Again, the multidisciplinary approach needs to be highlighted. This sub-section needs to constitute the greater part of the unit. Candidates need to carry out at least **one** forensic analysis using each of the following areas:

- biological;
- chemical;
- physical.

There is a wide range of activities from which to choose, but it must be ensured that these are sufficiently complex to allow the collection and analysis of numerical data. These activities might constitute parts of a crime-scene scenario, which would need careful planning.

The implications of the conclusions drawn from the information and data produced need to be considered. In order to draw conclusions from data, the need to use standards, published chemical data and spectra, and comparisons with databases, should be emphasised. Again, candidates need to consider the forensic implications of the data collected before producing their evaluation in their report in sub-section 3.6.3 *Evidence and proof*.

Evidence and proof

Candidates need to focus on a case study (real or fictitious) and discuss the strengths and weaknesses of the evidence involved. Higher-level candidates should be citing scientific reasons for the high or low level of reliability of the evidence in terms of ‘proof’. These candidates need to be discussing aspects such as points of comparison in fingerprints and test sites, and sex and coding areas in DNA analyses. They may also consider the probability that the evidence has come from a suspect rather than someone else, e.g. consider that a full DNA analysis gives results that are accurate to one in a billion: in a country with a population of 60 million, a match could be considered ‘conclusive’ proof. For higher-level candidates, there is an opportunity to introduce data on gene frequencies and carry out some calculations of allele frequency from data on the occurrence of phenotypes (Hardy-Weinberg equation).

The work of the forensic scientist in assisting in the conviction or acquittal of a suspect depends on quality evidence, and candidates need to research the various ways in which this is ensured. The limitations of types of evidence should be researched and discussed in detail. Candidates also need to discuss the need to review evidence when new scientific techniques are developed. They could examine miscarriages of justice, or cases where contemporary forensic evidence has established guilt. Suitable cases for research and discussion include Mary Druhan, Mark Cleary, Peter Fell, Terry Allen, Omar Raddad, Paul Blackburn, Sheila Bowler, Gary Mills and Tony Poole, John Alexander Dickman, Robert William Hoolhouse, the 'Birmingham Six', the 'Bridgewater Four', Derek William Bentley, the 'Guildford Four', James Hanratty, Judith Minna Ward, Stefan Ivan Kiszko and Timothy John Evans.

Guidance on Assessment

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The further guidance below amplifies the criteria in the *Assessment Evidence Grid* and will help the candidate to determine the appropriate mark to be awarded for each strand.

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<tr><td rowspan="2">AO1</td><td>1</td><td>• At this level, the candidate describes in basic terms why the crime scene has to be preserved and recorded before disturbance;
• they describe, in basic terms, how a limited number of types of forensic evidence are searched for, then collected safely, using chemical, biological and physical techniques – at least one technique from each of physical, biological and chemical techniques needs to be described;
• they give reasons for careful collection of evidence limited to the principles of avoiding contamination and for the safety of the forensic scientist, but give no details;
• there will be evidence of some scientific terminology and corrected punctuation and grammar;
• some basic information on the ethics of retaining samples and data needs to be included;</td></tr>
<tr><td>2</td><td>• at this level, the candidate shows that some research has been carried out to describe why the crime scene has to be preserved and the principal ways in which this is carried out;
• they describe how types of forensic evidence are searched for, indicating that the search is thorough and systematic and give a basic description of the approach;
• candidate describes the collection of a range of different types of forensic evidence, using a variety of chemical, biological and physical techniques, giving information on the situations in which these techniques are used;
• they give reasons for careful collection of evidence, suggesting how contamination is avoided using the various methods; they describe safety measures taken by the forensic scientist and how risks can be minimised;
• they will correctly use appropriate scientific terms, and correct punctuation and grammar;
• their work needs to show information on a range of ethical issues related to suspects and those convicted and to be aware of the current legal framework;</td></tr>
</table>

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
	3	• at this level, the candidate describes and explains in detail why, and how, the crime scene is preserved, e.g. first of all defining the crime scene area, then the exclusion of other people, barricading or roping off the area, protection from the elements, positioning of guards; • they explain the need for recording before disturbance and their description of the methods used include modern techniques and where appropriate, the science behind them; • they describe how a variety of different types of forensic evidence are searched for, defining search patterns, if appropriate, and techniques; the candidates then describe how a range of different types of evidence is collected, using chemical, biological and physical techniques and discussing alternative techniques for collecting similar types of evidence; • they give reasons for careful collection of evidence, illustrating how different types of evidence may be subject to different types of contamination and how measures are taken to prevent this; a description of safety measures includes how these prevent risk from a variety of hazards; • they will understand the science behind these techniques and use appropriate scientific terms and conventions correctly, with correct spelling, punctuation and grammar; • their work needs to show an understanding of ethical issues and include relevant points from the current legal framework.

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO2	**1**	• At this level, the candidate completes a report based on some of the bullet points in sub-section 3.6.3 Evidence and proof; • candidate may use an actual case study or a fictitious one; • candidate outlines the need for the collection of quality evidence and defines the basic principles involved in standardising methods of analysis; • they describe the chain of evidence that may lead to a conviction; • they state the strengths and limitations of some types of forensic evidence; • candidate includes work showing straightforward calculations (see Appendix C for examples) which use data from candidates' own practical work or taken from case-study material;
	2	• at this level, the candidate completes a report based on the bullet points in sub-section 3.6.3 Evidence and proof; • candidate uses an actual case study or a fictitious one; • candidate outlines the need to collect evidence and the procedures for the collection of quality evidence by listing the agencies involved and stating the principles involved in standardising methods of analysis; • they describe the chain of evidence that may lead to a conviction; • they state the strengths and limitations of a range of different types of forensic evidence and carry out some interpretation; • candidates include work showing straightforward calculations (see Appendix C for examples) which use a range of data from candidates' own practical work or that taken from case-study material – solutions will be correct;
	3	• at this level, the candidate completes a report based on the bullet points in sub-section 3.6.3 *Evidence and proof*; • candidate uses an actual case study or a fictitious one; • candidate describes the involvement of all the various agencies for the collection of quality evidence and explains the processes involved in standardising methods of analysis – they state the limitations, strengths and weaknesses of a wide range of types of forensic evidence, illustrate these with examples for each type and quantify these where appropriate; they show evidence of interpretation in assessing the probability of guilt; • they fully describe the chain of evidence that may lead to a conviction; • candidate gives evidence of the need to review in the light of new scientific development; • candidate includes work showing *complex* calculations (see Appendix C for examples) which use a range of data from candidates' own practical work or that taken from case-study material – solutions will be correct.

<table>
<tr><th colspan="3">Amplification of Criteria</th></tr>
<tr><th>AO</th><th>Mark Band</th><th>Characteristics of the work one may expect to see at this mark band can be summarised as follows:</th></tr>
<tr><td rowspan="3">AO3</td><td>1</td><td>• Candidate uses a risk assessment to show safe working where appropriate;
• they take at least one set of forensic measurements from each area of forensic analysis – see sub-section 3.6.2 Methods of analysis of evidence;
• they record observations and measurements and the data are displayed appropriately, with help;
• candidate attempts to interpret the results and relates them to the forensic investigation;</td></tr>
<tr><td>2</td><td>• candidate carries out risk assessments consistent with COSHH guidelines before each relevant activity to show safe working;
• they take at least one set of forensic measurements from each area of forensic analysis – see sub-section 3.6.2 Methods of analysis of evidence;
• they work with an appropriate degree of accuracy, using a range of techniques;
• they record relevant observations and measurements from the above experiments and the data are displayed accurately, without help;
• they display results accurately in a range of ways;
• candidate processes results and draws basic conclusions interpreting the results and relating them to the forensic analyses;</td></tr>
<tr><td>3</td><td>• candidate takes measurements and make observations using the most appropriate techniques and equipment for each type of evidence in sub-section 3.6.3 Methods of analysis of evidence;
• they repeat measurements, explaining the need to repeat;
• they work with an appropriate degree of accuracy;
• they record relevant observations and measurements from the above experiments and the data are displayed accurately, without help;
• they display results accurately in a range of ways;
• candidate draws conclusions interpreting the results and relates them to the forensic investigation.</td></tr>
</table>

Resources

Organisations

The Environment Agency
The Forensic Science Service
The Laboratory of the Government Chemist

Textbooks

Ballard D *et al.*	*OCR A Level Applied Science*	Heinemann	978 0435692 12 4
Jackson ARW & Jackson JM	*Forensic Science*	Pearson Education	013 043 251 2
Nickell J & Fischer JF	*Crime Science*	The University Press of Kentucky 1998	081 312 091 8
Owen D	*Hidden Evidence*	Quintet Publishing 2001	186 155 365 X
Platt R	*Crime Scene: The Ultimate Guide to Forensic Science*	Dorling Kindersley 2003	075 134 576 8
Saferstein R	*Criminalistics*	Prentice-Hall 2001	013 013 827 4
White P (ed)	*Crime scene to court*	RSC 1998	085 404 539 2

Websites

Contamination and explosives - www.fsni.gov.uk

Crime scene investigator – collection/visualisation of evidence - www.crime-scene-investigator.net/

Drugs - www.druglibrary.org/schaffer/index.HTM
- www.interpol.int/Public/Drugs/synthetic/default.asp

Drugs in sport - www.biomedcentral.com/1471-8219/1/3

Environment Agency - www.environment-agency.gov.uk

FBI's handbook of forensic sciences - www.fbi.gov/hq/lab/handbook/forensics.pdf

Fire scene investigator, including mass spectrometry - www.kore.co.uk/appnote_tcat_fire.htm

Firearms - www.firearmsid.com

Forensic odontology - www.bafo.org.uk

Forensic Science Service – has a comprehensive reading list - http://forensic.gov.uk/

Forensic Science weblinks - www.tncrimlaw.com/forensic

George Washington University weblinks - www.gwu.edu/~forensic/

Laboratory of the Government Chemist - www.lgc.co.uk

Metropolitan Police Service site - www.met.police.uk/index

National Center for Forensic Science - http://ncfs.ucf.edu

Unit G626: The Physics of Sport

Guidance on Delivery

This unit focuses on some of the applications from Unit G630: *Materials for a purpose*. This unit allows for extensive coverage of such applications within the context of the vocational area of sport.

The emphasis of the unit is to develop an understanding of how physical factors of science influence the effect and performance of sport. Candidates need to consider how the technology behind sporting equipment has enabled the performance of sportsmen and women to be improved. Candidates need to refer to information from everyday sources such as advertisements, magazine articles and websites.

Throughout the unit, candidates need to be encouraged to carry out their own research into how the physics of materials affects sporting equipment and subsequent sporting performance.

Measurement

An overview and discussion of the reasons why accurate measurements in the sporting world are of such importance needs to be undertaken. This section builds on work at Key Stage 4 and GCSE Applied Science in relating the scientific and physical units used.

Candidates need to become familiar with SI units and submultiples. Candidates need to use and convert these units in context with sporting measurements, e.g. weight- or power-lifting and the use of kilograms (kg) and pounds (lbs), time in relation to seconds, hundredths and thousandths of a second.

Such understanding of SI units can be taught through isolated exercises involving conversions and calculations or through experimental methods and techniques.

Candidates need to research and study the range of devices and techniques that allow measurement in sport to be made. These can be researched and investigated through experimental work. Candidates themselves could engage with sports or training equipment such as treadmills, exercise bikes, rowing machines, running, swimming and cycling. Candidates can record and monitor timings, changes in body temperature, peak flow – lung capacity, pulse and heart rate. Data logging equipment, such as that from *Phillip Harris,* can be used to monitor such changes, and data developed, manipulated and presented in different formats. Devices need to be calibrated as part of experimental procedures, evidence that can then be used to assess the limitations of devices and comparisons can be made, e.g. manual clock versus electronic stop-clock.

Physics of the body

A variety of assessment activities can be used to measure achievement of the outcomes in this section. These need to involve candidates in a practical analysis, where possible, and need to be supported by scientific analysis, highlighting the relevant biological and physical principles. This needs to be supported by relevant external visits to facilities where biomechanical analysis takes place. Coaches and guest speakers will support the delivery and add relevance to underpinning knowledge.

One approach to this section is to overlap relevant text from GCE Physics and Human Biology. Candidates need to be familiar with the central nervous system from the relevant GCE Biology text. A diagram/model will help candidates to gain a better understanding of the anatomy of the eye. For knowledge of real images, the use of ray diagrams can aid the understanding of this area.

Candidates can research new vision technology to understand how contact lenses and spectacles can help sports players in areas such as tennis, snooker and aviation. Candidates can investigate wavelength changes through experimental work to determine how coloured filters affect white light.

The principle of moments can be taught instructively and calculations used to support this. To optimise movement in sport and exercise, the coach or instructor needs to be aware of how the force generated by muscle groups across a joint can be used to develop a range of movement in other joints and muscle-groups.

Physics equipment and techniques

Candidates need to research relevant/related articles from newspapers, magazines, journals and websites to appreciate how the performance in many sporting areas has been improved by the use of new materials such as composites.

Candidates need to learn through discussion to enable them to appreciate that the change in ‘physical properties’ of materials has improved performance in many sporting areas, such as professional tennis, golf, skiing, rowing, and motor racing. By improving the physical properties of a material, the energy and momentum of performance can be changed and candidates need to be clearly taught about the principles of ‘conservation of energy and momentum’ through instructive and experimental delivery.

GCE Physics texts will provide further explanations on rotating objects – circular motion having both kinetic energy and momentum, and how a change in shape may lead to a change in rotation when applied to various sporting examples, e.g. discus, hammer and badminton. One such experiment can be followed through the SATIS module.

Candidates need to show a clear understanding of physical properties terminology to enable them to differentiate between strength, elasticity, toughness, brittleness, stiffness and density. These properties need to be considered carefully when designing new sporting equipment. A small change in density of a material can have a significant effect on the performance of equipment. Candidates also need to be made aware that there is a great deal of dependency on each property in relation to others and compensation is often needed with physical properties when designing performance materials. Candidates need to refer to a glossary on physical properties similar to that used in Unit G630: *Materials for a purpose* and to identify, select and process information. It would be preferable to introduce the properties as they arise in discussions of materials types, perhaps also encouraging candidates to build up their own list of definitions.

One approach to teaching about a class of materials is to start with a set of ten or more samples that are in the teaching environment or are brought in from outside. These will include types of metals, ceramics, polymers and old composites and new, e.g. glass-reinforced plastic. Candidates can then work in groups to discuss what properties the samples have that make them suitable for their given purpose. Some of the items may well include sporting equipment, e.g. cricket bat, tennis racket or fishing rod.

The study of the effects of spin on the trajectory and bounce of a ball along with forces and motion of sails can be followed through GCE Physics and Sports Science texts.

Guidance on Assessment

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

You need to mark each portfolio according to the assessment objectives and content requirements in the *Assessment Evidence Grid* (Appendix B).

The information on this *grid* will eventually be transferred onto a *Unit Recording Sheet* to be attached to the front of each candidate's piece of work at the point when the work is submitted for moderation. A *Coursework Administration Pack* will be supplied, containing all relevant *Unit Recording Sheets*. Where marking for this unit has been carried out by **more than one** teacher in a centre, there must be a process of internal standardisation carried out to ensure that there is a consistent application of the criteria as laid down in the *Assessment Evidence Grids*.

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

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

You use your professional judgement to determine which descriptor in a strand best suits the individual candidate's work and from the range of marks available within that particular mark band, you circle the mark that best fits the work. You then record this mark (or sum of marks if there is more than one row for that particular assessment objective) in the column headed *Mark*.

You need to use the full range of marks available to you. You need to award full marks in any strand for work which fully meets the criteria. This is work which is the best one could expect from candidates working at AS level.

Only **one** mark per AO strand will be entered (although this may be the sum from several rows – **one** mark per row – for that particular AO strand). The final mark for the candidate is out of a total of **50** and is found by totalling the marks for each AO strand.

The further guidance below amplifies the criteria in the *Assessment Evidence Grid* and will help the candidate to determine the appropriate mark to be awarded for each strand.

Amplification of Criteria		
	Mark Band	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO1	**1**	• Candidate produces **four** leaflets outlining the facts, phenomena and principles; • the summaries include relevant material that they have researched;
	2	• candidate demonstrates a sound and detailed understanding of the facts, phenomena and principles; • this may include analysed scientific data, but may have few minor omissions but scientific data is precise;
	3	• candidate gives a full and comprehensive demonstration of knowledge and understanding of facts, phenomena and principles; • candidate shows detailed evidence of these.
AO2	**1**	• Candidate selects appropriate materials for each of the chosen applications; • a clear explanation of each technique is required; • spelling, punctuation and grammar is correct; • candidate performs basic calculations to support some mathematical input;
	2	• candidate identifies clearly the underlying principles relating to choice of materials for each of the applications with only minor omissions or errors; • spelling, punctuation and grammar is correct; • candidate shows appropriate use of mathematics to support their work;
	3	• candidate identifies clearly, logically and accurately the underlying principles relating to choice of materials for each of the applications; • a detailed explanation of the principles is required; • spelling, punctuation and grammar is correct; • candidate shows confident and accurate use of mathematical techniques – these are appropriate and relevant to enhancing detailed explanations.
AO3	**1**	• Candidate presents simple experimental plans that shows awareness of safety; • the experiments show the use of a range of equipment in obtaining valid data; • investigative work has been carried out safely – interpretation of results has been undertaken and related to investigations;
	2	• candidate uses a range of techniques and equipment; • investigations are conducted safely to obtain adequate and valid data; • repeat measurements undertaken as part of the investigations; • recorded data is presented in a suitable format with an appropriate degree of precision; • interpretation of results is undertaken and basic conclusions relating to the investigations are drawn;
	3	• candidate uses a wide range of techniques and equipment; • investigations are conducted safely to obtain adequate and ample data; • repeat measurements undertaken as part of the investigations; • clearly recorded data to an appropriate level of precision; • undertake detailed interpretation of results and draw conclusions; • discussion of conclusions' significance to the investigations.

Resources

Publications

Advanced GNVQ Unit 2: Investigating materials and their uses, pg 66-122 Heinemann

GNVQ Advanced Assignments, Nuffield Science in Practice,
Unit 2: Investigating materials and their uses - Assignment 7: Spectacle lenses pg 61-72

SATIS 14-16 Unit 209: Information on contact lenses
Assignment 9: Modifying materials pg 79-87

SATIS 16-19 Science and technology in society Units 76-100 1992
Unit 99: Making a racket
Unit 100: Racket games – the physics of rackets 086 357 163 8

Textbooks

Ballard D *et al.*	*OCR A Level Applied Science*	Heinemann	978 0435692 12 4
Beashel P & Taylor J	*Sport Examined*	Nelson	
Brimicombe M	*Physics in Focus,* Chapters 3, 5 and 2	Nelson 1990	017 448 1748
Hawkey R	*Sport Science*	Hodder 1991	
Leybold H	*Physics Catalogue of Experiments* Chapters 7,8,9,and 34		
Parker K & Parry M	*Physics of Sport* (*Supported Learning in Physics Projects)*	Heinemann	043 568 845 6
Wirhed R	*Athletic Ability and the Anatomy of Motion*	Mosby-Wolfe 1997	

Websites

Australian Academy of Science: Measurement in sport – the long and the short of it - http://www.science.org.au/nova/033/033key.htm

Exploratorium: Sport Science – Baseball, skateboard, surfing, cycling, hockey - http://www.exploratorium.edu/sports/

Links - www.teach-nology.com/teachers/subject_matter/physical_ed/physics/

Winter Olympics, Sport and Science, Physics and Biomechanics
The Physics of Luge
The Science of Jumping and Rotating
http://btc.montana.edu/olympics/physbio/default.htm

Unit G627: Investigating the Scientist's Work

Guidance on Delivery

The intention is that this unit will provide candidates with time to work on projects that reflect the activities of scientists in the workplace. It has been designed to allow candidates scope to draw on knowledge, understanding and skills gained from other units, as well as knowledge which will be gained specifically for this investigation. The investigation needs to, as far as possible, replicate a real working situation and be subject to constraints of deadlines, support and resources. The topic chosen needs to have some vocational/real life context.

Planning an investigation

Sub-section 3.8.1 *Planning an investigation* provides opportunities for candidates to determine their own aims and objectives, although they need to agree these before beginning the investigation, (one overall topic could be set for a group if staff are not confident in candidates working on different investigations). Research needs to include accessing secondary sources (paper-based, electronic and human) and making decisions about what is relevant and what needs to be disregarded. The investigation may be devised in liaison with industry, universities or institutions such as hospitals or other service providers if the appropriate contacts can be found. In this instance, plans need to be made to fit in with the organisation concerned.

Candidates need to be aware of:

- the necessary scientific knowledge, theories, concepts and ideas;
- the time available, including access to laboratories and computer facilities;
- resources including chemicals, apparatus, support materials;
- health and safety requirements;
- travel costs, risk assessments etc. if required;
- any ethical issues which may need to be considered, e.g. guidance on testing.

Carrying out the investigation

In the workplace, scientists need to work reliably, accurately and with precision. The practical work that candidates carry out needs to be at A2 standard and give them the opportunity to work accurately and to the appropriate precision, e.g. when choosing the appropriate instrument/piece of apparatus. The investigation needs to be targeted at this level and allow candidates to learn some new techniques, as well as using ones covered in previous units. Candidates may work within a team, but where this happens, the work of other members of the group needs to be fully acknowledged. Candidates, however, need to show individual results and conclusions. Any teamwork needs to be acknowledged in the plan.

Processing and presenting data

Techniques for processing data include arithmetic, statistics, use of equations, use of spreadsheets, graphs and gradients. Formats for recording data include text, charts, tables, diagrams, bar charts, histograms and graphs. Candidates need to have practice in processing data before they use the techniques in their investigation.

Presenting the outcomes of the investigation

The completion of this work gives candidates the opportunity to present the outcomes of their investigation in a variety of ways: a written report, a verbal presentation with evidence of what was said, e.g. a PowerPoint presentation, suitable leaflets/booklet.

The complete evidence for this unit is an information pack, which includes all the evidence to cover all assessment objectives.

Suggested ideas for investigations

- Investigation into the properties of polymers (physical and chemical)
- Fermentation
- Enzyme activity
- Physics of moving objects
- Vitamin C and iron in foods
- Investigations involving: smokers, peak flow, cardiac recovery, exercise
- Environmental investigations

Guidance on Assessment

Candidates need to carry out research for this unit, they need to be taught how to find, select and record the relevant information and its source. Coursework needs to include diagrams, tables, charts, graphs and calculations that are accurate to the correct degree. Candidates need to interpret their findings and draw conclusions.

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

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

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

You need to mark each portfolio according to the assessment objectives and content requirements in the *Assessment Evidence Grid* (Appendix B).

The information on this *grid* will eventually be transferred onto a *Unit Recording Sheet* to be attached to the front of each candidate's piece of work at the point when the work is submitted for moderation. A *Coursework Administration Pack* will be supplied, containing all relevant *Unit Recording Sheets*. Where marking for this unit has been carried out by more than **one** teacher in a centre, there must be a process of internal standardisation carried out to ensure that there is a consistent application of the criteria as laid down in the *Assessment Evidence Grids*.

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

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

You use your professional judgement to determine which descriptor in a strand best suits the individual candidate's work and from the range of marks available within that particular mark band, you circle the mark that best fits the work. You then record this mark (or sum of marks if there is more than one row for that particular assessment objective) in the column headed Mark.

You need to use the full range of marks available to you. You need to award full marks in any strand for work which fully meets the criteria. This is work which is the best one could expect from candidates working at A2 level.

Only **one** mark per AO strand 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 AO strand.

The further guidance below amplifies the criteria in the *Assessment Evidence Grid* and will help the candidate to determine the appropriate mark to be awarded for each strand.

<table>
<tr><th colspan="3">Amplification of Criteria</th></tr>
<tr><th>AO</th><th>Mark Band</th><th>Characteristics of the work one may expect to see at this mark band can be summarised as follows:</th></tr>
<tr><td rowspan="2">AO1</td><td>1</td><td>• The plan includes evidence that candidate has demonstrated some knowledge and understanding of science, recognised and recalled facts and have included some scientific terminology and practical techniques;
• they have selected, organised and presented the information for the plan from information that has been provided or acquired through their own research about the investigation, some references are evident ;
• details for the plan include information as shown in sub-section 3.8.1 Planning an investigation – some omissions are acceptable at this level;</td></tr>
<tr><td>2</td><td>• candidate's work has few omissions or inaccuracies though some areas may not be as extensively covered as others;
• the plan includes evidence that candidates have recognised and recalled facts, terminology and practical techniques;
• they have selected, organised and presented the information for the plan and the investigation from information that has been acquired through their own research with related referencing of sources used;
• details for the plan includes information as shown in sub-section 3.8.1 Planning an investigation – some detailed information is needed on some bullet points listed;</td></tr>
<tr><td>AO1</td><td>3</td><td>• candidate's work demonstrates that they have used their knowledge and understanding from other units in the specification with no omissions;
• the plan includes evidence that candidates have recognised and recalled facts, principles, concepts and practical techniques and used scientific terminology accurately;
• they have selected, organised and presented relevant information for the plan and the investigation from information that has been acquired through their own research and related referencing is evident;
• details for the plan include information as shown in sub-section 3.8.1 Planning an investigation – detailed and logical information is needed on all bullet points listed.</td></tr>
</table>

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO2	**1**	• Candidate should show evidence they have monitored their plan giving appropriate reasons which indicate their understanding; • candidate’s evidence gives limited interpretation of the success of the investigation with some link to a vocational input; • the data processed should include evidence that candidate has carried out *straightforward* calculations (see Appendix C), sometimes obtaining mainly the correct solutions;
	2	• candidate should show evidence they have monitored their plan giving modifications and changes with appropriate reasons which indicate their understanding; • candidate's evidence should demonstrate a discussion about the reliability of the data/results collected and outcome of the investigation with a link to the original aims of the investigation, a vocational input is also needed; • the data processed should include evidence that candidate has completed and carried out some straightforward and *complex* calculations (see Appendix C) with partial success and accuracy;
	3	• candidate should show detailed evidence that they have monitored their plan giving appropriate reasons with detailed explanations of strategies used to overcome any problems they encountered, their explanations should indicate their understanding of the full investigative work; • candidate's evidence indicates an understanding of how the investigation achieved its aims and objectives with a detailed scientific discussion of the reliability of the work carried out; • the outcomes have been linked to the vocational context chosen; • the data processed should include evidence that candidate has carried out complex calculations (see Appendix C), obtaining the correct solutions to an appropriate degree of accuracy and giving answers to the correct significant figures.

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO3	**1**	• Candidate produces evidence which indicates that they have carried out practical tasks safely, using risk assessments, with the results suitably recorded this includes a record of coverage of most of the bullet points in sub-section 3.8.2 *Carrying out the investigation*; • candidates produce a clear and accurate report providing some interpretation of results with a basic evaluation (this report can be a written report, presentation poster, video or any other appropriate medium) suitably presented for the given audience; • the report shows evidence that spelling, punctuation and grammar has been corrected; • record of the data collected and how it was processed which includes the details as shown in sub-section 3.8.3 *Processing and presentation of data from the investigation*; • evidence shows that basic scientific terminology has been used correctly; • a candidate at this level is expected to show basic coverage of the requirements of sub-sections 3.8.4 *Evaluation of the investigation* and 3.8.5 *Presentation of the outcomes of the investigation* – some omissions are acceptable;
	2	• candidate produces evidence which indicates that they have carried out all practical tasks safely and skilfully using suitably detailed risk assessments; • experimental work demonstrating a range of techniques has been used with the appropriate degree of accuracy, if appropriate, and all relevant results recorded; • their investigation has been well planned and followed with a suitable record which incorporated amendments where appropriate; • a record of the data collected and how it was processed which includes the details as shown in sub-section 3.8.3 *Processing and presentation of data from the investigation*; • candidate produces a logical and accurate report providing interpretation of results with a good evaluation (this report can be a written report, presentation poster, video or any other appropriate medium) suitably presented for the given audience; • evidence shows that scientific terminology has been used correctly and understood; • the report shows evidence generally of the correct use of punctuation and grammar; • a candidate at this level is expected to show coverage of all the requirements of sub-sections 3.8.4 *Evaluation of the investigation* and 3.8.5 *Presentation of the outcomes of the investigation* – limited detail in some areas is acceptable;

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
	3	• candidate produces evidence which indicates that they have carried out all practical tasks safely and skilfully, using risk assessments which they have produced; • experimental work demonstrating a range of techniques has been used with the appropriate degree of accuracy and the results recorded with appropriate precision; • their investigation has been independently planned and followed with suitable critical evaluation, incorporating amendments where appropriate; • a record of the data collected and how it was processed which includes the details as shown in sub-section 3.8.3 *Processing and presentation of data from the investigation*; • candidate produces a logical and well structured report providing detailed interpretation of the outcomes with a basic evaluation (this report can be a written report, presentation poster, video or any other appropriate medium) suitably presented for the given audience; • evidence that fluent scientific terminology has been used and understood correctly; • the report shows evidence of correct spelling, punctuation and grammar; • a candidate at this level is expected to show detailed coverage of all the requirements of sub-sections 3.8.4 *Evaluation of the investigation* and 3.8.5 *Presentation of the outcomes of the investigation*.

Resources

Organisations

It is suggested that if centres wish to link the investigations to an organisation they use:

- breweries;
- fitness centres;
- health centres;
- local University Science Departments;
- opticians.

Some local industries have facilities for candidates to work on-site (need to check risk assessments/health and safety guidelines).

Textbooks

	GNVQ Science Advanced Nuffield Science in Practice	Heinemann	043 563 2531
Gadd K & Holman J (eds)	*Advanced Science*	Nelson	017 448 2353

(Both books are based on old specifications, but content is still useful).

David Ballard *et al.*	*OCR A Level Applied Science*	Heinemann	978 0435692 12 4

For practical information – use of any GCE Chemistry/Biology Physics Practical textbook will contain ideas for practical work.

Good references to ethical issues can be found in SATIS units:

What is Science?	086 357 158 1
What is Technology?	086 357 159 X
How Does Society Decide?	086 357 160 3

Websites

Department for Business, Enterprise & Regulatory Reform
www.berr.gov.uk

Natural Environment Research Council
www.nerc.ac.uk

Office for National Statistics
www.statistics.gov.uk

Royal Society of Chemistry
www.rsc.org

Soap and Detergent Industry Association
www.chemsoc.org

UK Cleaning Products Industry Association
www.ukcpi.org

University of York Education, Chemical Industry Education Centre
www.ciec.org.uk

Unit G628: Sampling, Testing and Processing

Guidance on Delivery

There are many opportunities to gather evidence for help in this unit while candidates are working on other units. For example:

- G621: *Analysis at work* – physiological measurements related to the human circulatory and respiratory systems;
- G625: *Forensic science* - wide ranging aspects of science that are used in a court of law;
- G629: *Synthesising organic chemicals* – the preparation of organic compounds in the laboratory and the scaling up of these reactions.

Samples for analysis can be taken from a range of situations, e.g. samples could be collected from the environment (rock samples, rivers and living organisms). Another source of samples might be from a production-line of a local company as well as samples made during processes being carried out in your centre's laboratory.

Candidates need to be aware of the need for maintaining sample integrity and need to consider problems of contamination and of decomposition on standing.

Details of standard methods of sampling and testing can be obtained from a number of sources, e.g. from local companies or from hospital laboratories. Details are also obtainable electronically and from the *British Standards Institute* as well as from books and journals. Some methods are necessarily complicated and you may need to interpret them and modify them as required.

Testing procedures will produce data that can be handled in a variety of ways, from simple calculations, particularly those involving percentages, to graphs and other diagrammatic representations.

Candidates need to have some experience of small-scale processing in the laboratory. The purpose of small-scale processing in industry includes:

- producing small quantities of substances which can be used as reference standards;
- producing small quantities of a product for which there is a specialist need;
- testing the viability of a process before large-scale production.

Examples of suitable small-scale processing might include the:

- manufacture of a material, e.g. an alloy, ceramic or chemical compound;
- modification of an existing compound or material to fit a new requirement, e.g. in polymers and composites;
- recycling and recovery of materials, e.g. metals, solvents, paper, polymers;
- formulation of a product by combining together different components, e.g. cosmetics, compound fertilisers, washing materials.

There are many possibilities in other units for investigations in this area.

The external assessment for this unit will explore this topic from a wider vocational perspective.

Stretch and Challenge

Stretch and challenge is in this unit is achieved by

- inviting a greater depth of thinking in candidates answers.   The words analyse, evaluate or discuss might be used in the question introduction
- asking short answer style questions which cover different parts of the specification within the context of just one vocational situation
- encouraging more extended writing, so giving the opportunity to give in-depth answers and to gain the full range of quality of written communication marks.

Guidance on Assessment

This unit is assessed through pre-released case study material and a 1½ hour question paper with **90** marks which assesses AO1 (**45-55** %) and AO2 (**45-55** %).

There are **three** questions, mainly of short-answer style whilst some question part(s) will give candidates the opportunity to present their response by means of continuous prose.

Two of the questions will be based on the pre-released case study material, which will be circulated to centres prior to the examination.

Questions will be set on the applications of other units with regard to sampling, testing and processing.

Resources

Centres should consult the resource material given in other units and use this in conjunction with specific references to techniques of sampling, testing and processing in the publications outlined below.

Organisations and Websites

The British Standards Institute - www.bsi.org.uk

The Institute of Biology - www.iob.org

The Institute of Physics - www.iop.org

The Royal Society of Chemistry - www.rsc.org

Publications

British Pharmacopoeia
Chemistry and Industry
Chemistry Review
New Scientist

Textbooks

Ballard D *et al.*	*OCR A Level Applied Science*	Heinemann	978 0435692 12 4
Jeffery GH *et al*	*Vogel's Textbook of Quantitative Chemical Analysis*	Longman 1989	058 244 693 7
Radojevic M & Bashkin V	*Practical Environmental Analysis*	The Royal Society of Chemistry 1999	085 404 594 5
Faust CB	*Modern Chemical Techniques*	The Royal Society of Chemistry 1992	1-870343-19-0

Information gained during visits to local organisations for G620: *Science at work* will help to show the relevance of this unit.

Unit G629: Synthesising Organic Chemicals

Guidance on Delivery

This unit draws on the scientific knowledge, skills and understanding provided by the study of G620: *Science at work*, G621: *Analysis at work* and G622: *Monitoring the activity of the human body*. It also develops the organic component of G624: *Chemicals for a purpose*.

It is important that candidates become familiar with and confident in using standard chemical substances and laboratory equipment. Correct nomenclature and terminology need to be embodied within the delivery, whilst the underpinning chemical principles need to be introduced gradually as the unit progresses, using practical sessions to support the theory wherever possible.

Practical work is an integral part of the unit and the skills required for the preparation and analysis of the organic compounds can be developed through a practical based approach to the underpinning theory. This allows candidates with all learning styles the opportunity to understand the basic chemistry requirements for the unit.

The principal aim of the unit is to give candidates a sufficient grounding in theoretical and practical organic chemistry to allow them to appreciate the work and contribution made by the organic chemist to modern day living and realise the diversity of their work.

Organic compounds and functional groups

This allows candidates to build on their skills, knowledge and understanding from GCSE Science and from the AS units within this qualification.

Candidates need to know about functional groups and how they are named, and 3D shapes of organic molecules and their properties. They need to understand that single covalent bonds are free to rotate (unless hindered by bulky functional groups) but multiple bonds are not. The effect of intermolecular forces on the properties of organic molecules need to be emphasised and candidates need to use paper and electronic sources of information to find out about their properties. Candidates need to know about both stereo isomerism and structural isomerism and the effect they have on the properties of a compound. In particular, stereo isomerism needs to be related to drug activity in the body.

The use of molecular models (both Molymod models and electronic models) needs to be used to demonstrate 3D shape and isomerism.

Types of chemical reaction

Candidates need to classify reactions as:

- substitution, e.g. Friedel-Crafts reactions
- addition, e.g. hydrogenation reactions
- redox (oxidation and reduction), e.g. the oxidation of primary alcohols to carboxylic acids
- esterification, e.g. the preparation of Germolene and aspirin
- hydrolysis, reaction with water, e.g. hydrolysis of amides and esters
- polymerisation, addition and condensation, e.g. preparation of nylon

They need to be able to write balanced chemical equations for the reactions they use in the synthesis.

Making and purifying organic compounds

Candidates need to be familiar with the correct usage of the following processes and apparatus:

- containing and transferring chemicals, for example:– beakers
  – conical flasks
  – test tubes
  – boiling tubes
  – spatulas
  – dropping pipettes
  – delivery tubes
  – quick fit apparatus

- measuring and monitoring:
  – volume, e.g. graduated beaker, measuring cylinder, burette, one-line and graduated pipettes
  – mass, e.g. top-pan balance
  – temperature, e.g. thermometer, thermocouple
  – time, e.g. stop-clock

- heating, for example:
  – reflux
  – bunsen burner
  – electric heating mantle
  – water bath
  – oil bath
  – electric hot-plate
  – heat-proof mats
  – tongs
  – test-tube holders

- cooling, e.g. ice baths, condensers and water baths

- mixing, e.g. stirring rod and magnetic stirrers

- separating and purifying:
  – solvent extraction
  – filtration, e.g. atmospheric and reduced pressure
  – evaporation
  – distillation
  – recrystallisation

- determining purity:
  – melting and boiling points
  – titration
  – chromatography
  – *spectroscopic methods could be used*

All work should be carried out only when a valid risk assessment has been made and candidates need to pay due regard to the risk assessment.

Determining yield and purity

Candidates should be familiar with purifying products and assessing purity using the methods described. They then need to process their data to calculate percentage yield of a preparation. In addition, they need to perform calculations to determine the quantities of reactants needed to produce a theoretical amount of product for reactions other than those carried out. Candidates need to locate relevant published data from a variety of sources, compare their experimental data and draw conclusions.

Therapeutic drugs and medicines

Hospitals and local pharmacists may be able to provide candidates with expert advice. This may be in the form of a visit to a local hospital and/or a visiting speaker. Not all drugs have complex structures, less complex ones such as aspirin, paracetamol and ibuprofen can be used to illustrate molecular shape. Candidates can also build molecular models of these compounds, prepare them and purify them in the laboratory. The Royal Society of Chemistry produces several publications outlining the history of such drugs, methods of preparation and ways of determining purity. General anaesthetics, such as ether and nitrous oxide, also have simple structures and would provide straightforward examples to study. CD-ROM simulations can be used to show the shapes of more complex molecules.

Industrial manufacture of chemical compounds

The development of a new compound from its production in the laboratory through to full-scale manufacture would provide an excellent case study. This allows for the requirements of the specification to be met by considering the factors to be taken into account when scaling up a process, an evaluation of the use of batch and continuous processes, the role of automation in both manufacturing and testing, health and safety implications and the costs associated with the process. The report could focus on a pharmaceutical product already studied, or make use of any local manufacturing facilities. An industrial visit or speaker would provide a great deal of useful information. Candidates need to be aware of how sampling and testing operations are carried out on an industrial scale as opposed to the school laboratory.

Guidance on Assessment

Candidates need to carry out research for this unit, they need to be taught how to find, select and record the relevant information and its source. Coursework needs to include diagrams, tables, charts, graphs and calculations that are accurate to the correct degree. Candidates need to interpret their findings and draw conclusions.

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

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

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

You need to mark each portfolio according to the assessment objectives and content requirements in the *Assessment Evidence Grid* (Appendix B).

The information on this *grid* will eventually be transferred onto a *Unit Recording Sheet* to be attached to the front of each candidate's piece of work at the point when the work is submitted for moderation. A *Coursework Administration Pack* will be supplied, containing all relevant *Unit Recording Sheets*. Where marking for this unit has been carried out by more than **one** teacher in a centre, there must be a process of internal standardisation carried out to ensure that there is a consistent application of the criteria as laid down in the *Assessment Evidence Grids*.

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

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

You use your professional judgement to determine which descriptor in a strand best suits the individual candidate's work and from the range of marks available within that particular mark band, you circle the mark that best fits the work. You then record this mark (or sum of marks if there is more than one row for that particular assessment objective) in the column headed Mark.

You need to use the full range of marks available to you. You need to award full marks in any strand for work which fully meets the criteria. This is work which is the best one could expect from candidates working at A2 level.

Only **one** mark per AO strand 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 AO strand.

The further guidance below amplifies the criteria in the *Assessment Evidence Grid* and will help the candidate to determine the appropriate mark to be awarded for each strand.

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO1	**1**	• Candidate produces a report or a leaflet which shows knowledge and understanding of sub-sections 3.10.1 *Organic compounds and functional groups* and 3.10.2 *Types of chemical reaction* – some omissions are acceptable at this level but candidate aims to cover the majority of the information listed by the bullet points; **four** reaction types to be considered; • the report shows evidence that spelling, punctuation and grammar have been corrected; • some evidence of how material has been selected and linked to the work on therapeutic drugs etc. is shown; • candidate carries out some investigative work into the use and mode of action of **two** therapeutic drugs – examples of the information to be covered to be taken from sub-section 3.10.5 *Therapeutic drugs and medicines*;
	2	• candidate produces a report or a leaflet which shows a detailed knowledge and understanding of sub-sections 3.10.1 *Organic compounds and functional groups* and 3.10.2 *Types of chemical reaction* – candidate covers the majority of the information listed by the bullet points and are able to identify functional groups within organic molecules including therapeutic drugs; the importance of isomerism in shape and selective action and reactions is also included and candidate also shows evidence of the importance of the functional groups in determining the type of reactions; **four** reaction types to be considered; • the report shows evidence generally of the correct use of punctuation and grammar; • detailed evidence of how material has been selected and linked to the research work on therapeutic drugs etc. is shown; • candidate carries out their own investigative work into the use and mode of action of **three** therapeutic drugs – examples of the information to be covered to be taken from sub-section 3.10.5 *Therapeutic drugs and medicines*;

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
	3	• candidate produces a report or a leaflet which shows thorough knowledge and understanding of sub-sections 3.10.1 *Organic compounds and functional groups* and 3.10.2 *Types of chemical reaction* – candidate covers fully all the information listed by the bullet points and are able to identify, independently, functional groups within a variety of organic molecules including therapeutic drugs, the importance of isomerism in shape and selective action and are able to recognise different types of reactions; candidate also shows evidence that they know the importance of the functional groups in determining the type of reactions; **five** reaction types to be considered; • the report shows evidence of correct spelling, punctuation and grammar; • detailed evidence of how material has been selected and linked to the research work on therapeutic drugs etc. is shown; • candidate carries out their own detailed investigative work into the use and mode of action of at least three therapeutic drugs and show a thorough knowledge and understanding of the principles of drug action – examples of the information to be covered to be taken from sub-section 3.10.5 *Therapeutic drugs and medicines*.

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO2	**1**	• Candidate selects an appropriate organic compound that is manufactured on a large scale and focus on coverage of the requirements in sub-section 3.10.6 *Industrial manufacture of chemical compounds* – information on the reaction type and functional groups involved is included and all bullet points are considered, although some omissions are allowed; • evidence of sources used and how information was selected is included and work is clearly presented; • calculation work can include work on % yields and, if possible, costs involved in manufacture/production of organic compounds – if difficulties are encountered in obtaining this information, case study work can be used;
	2	• candidate selects an appropriate organic compound that is manufactured on a large scale and focus on detailed coverage of the requirements in sub-section 3.10.6 *Industrial manufacture of chemical compounds* – all bullet points are considered and some are discussed and explained in considerable detail; • evidence of a range of sources used and why information was selected should be included – work is clearly and logically selected and presented; • calculation work can include work on % yields and, if possible, costs involved in manufacture/production of organic compounds – if difficulties are encountered in obtaining this information, case study work can be used; the appropriate degree of accuracy should be used and work is correct;
	3	• candidate selects an appropriate organic compound that is manufactured on a large scale and apply scientific facts and understanding in order to cover all of the requirements in sub-section 3.10.6 Industrial manufacture of chemical compounds – all bullet points are considered and are discussed and explained in considerable detail; • evidence of a range of sources used and why information was selected is included – work should be clearly and logically selected and presented; • calculation work includes detailed work on % yields and costs involved in manufacture/production of organic compounds – if difficulties are encountered in obtaining this information, case study work can be used; the appropriate degree of accuracy is used and all work is correct – evidence of more complex calculations is shown.

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO3	**1**	• Candidate demonstrates that they have used risk assessments when carrying out both preparations and evidence is supplied that they have prepared the samples and used a range of techniques and equipment – one of the preparations is a useful drug but the other can be any suitable product chosen from sub-section 3.10.2 *Types of chemical reaction*; details needed are based on information listed in sub-section 3.10.3 *Manufacture and purification of organic compounds*; purifications need to be included in practical work; • some record has been made of relevant observations or measurements and some processing of results has been completed; • some guidance can be given at this level to conclusions and interpretation of work covered by the preparative work, some basic evaluation of the practical exercises should be included;
	2	• candidate demonstrate that they have used COSHH data to produce risk assessments and have safely completed both preparations – some guidance can be given to the production of the risk assessments; • evidence is supplied that they have done some planning in order to prepare the samples and used a range of techniques and equipment – one of the preparations is a useful drug but the other can be any suitable product chosen from sub-section 3.10.2 *Types of chemical reaction*; details needed are based on information listed in sub-section 3.10.3 *Manufacture and purification of organic compounds*; purifications need to be included in practical work; • records have been made, in a suitable format, of relevant observations or measurements and some processing of results has been completed – work shows the appropriate level of precision and accuracy; • candidate shows evidence of interpretation of their preparative work and draw some relevant conclusions; evaluation of the practical work should be completed with suggestions of alternative practical work that could be used to improve the yields either regarding preparation or purification;
	3	• candidate demonstrates that they have used COSHH data independently to produce risk assessments and have safely completed both preparations; • evidence is supplied that they have planned and skilfully prepared the samples and used a range of techniques and equipment with suitable justification for the use of the techniques – one of the preparations is a useful drug but the other can be any suitable product chosen from sub-section 3.10.2 *Types of chemical reaction*; details needed are based on information listed in sub-section 3.10.3 *Manufacture and purification of organic compounds*; purifications need to be included in practical work; • records have been made, in a suitable format, of relevant observations or measurements and there is correct processing of all results – all work shows the appropriate level of precision and accuracy; • candidate shows evidence of detailed interpretation of their preparative work with relevant conclusions and suitable explanations and detailed evaluation where appropriate, information on alternative techniques or preparative routes should be included.

Resources

Resources

Local hospitals and pharmacists can provide information about drugs and their mode of action. There are also many science books containing information about drugs.

If possible, arrange visits to appropriate chemical plants or visiting speakers.

Publications

Royal Society of Chemistry publications are an invaluable source of background information and preparative routes for organic compounds.

Examples include:

- Alchemy? Chemistry and industrial processes for schools and colleges. (CD- ROM);
- Analysts: Analytical science in action. (Video).
- Aspirin: a curriculum resource for post-16 chemistry courses;
- Industrial chemistry case studies;
- Paracetamol;
- Medicinal chemistry;
- The age of the molecule;
- Which compound? Which route?

The Chemical Industry Education Centre, University of York produces a range of useful materials.

SATIS 16-19 published by the Association for Science Education – it is advisable to access www.ase.org.uk as this gives information about these publications and is regularly updated:

Martin Green	The Pharmaceutical Business	APBI ISBN PHA BUS
	What is Science	086 357 1581
	What is technology	086 357 159X
	How Does Society Decide	086 357 1603

Data books including the Rubber Book give vast amounts of physical data.

Textbooks

Many advanced level chemistry books include sections on nomenclature and functional groups. There is also a variety of practical chemistry books that can be used to develop practical skills and provide preparative methods.

Ballard D *et al.*	*OCR A Level Applied Science*	Heinemann	978 0435692 12 4
Heaton A ed.	*An Introduction to Industrial Chemistry*	Kluwer 1995	
	The Essential Chemical Industry	University of York e-mail: ciec@york.ac.uk	835 432 577X
	Industrial Chemistry Case Studies	RSC	085 404 9258

Websites

Post-16 resources for science incl manufacturing and biotechnology
www.abpischools.org.uk

Educational resources, including free post-16 resources
www.gsk.com

The Royal Society of Chemistry homepage, providing links to other relevant sites
www.rsc.org
– excellent list of books/publications available access books for students
www.rsc.org/is/books/books_students.htm

Chemical industries education centre website offering many learning resources and useful links
www.york.ac.uk/org/ciec

Unit G630: Materials for a Purpose

Guidance on Delivery

This unit is about materials selection. In order to make informed choices between alternatives, it is necessary for candidates to learn something about the main classes of materials, their structure, and their properties. A large proportion of the delivery time of the unit will necessarily be taken up in covering these aspects. In order to keep the goal of materials selection in view, examples of applications to which materials are suited and applications requiring particular properties need to be stressed throughout.

The practical elements of the unit are important because they will help candidates to appreciate the very tangible nature of the concepts they are learning. Those who go on to follow courses in material engineering will encounter the full range of material testing available. Within this unit it is only possible to deal with a few examples in detail. Candidates, however, need to be aware that testing methods exist for all the properties they encounter in the unit.

Types of materials

One approach to teaching about a class of materials is to start with a set of, say, ten or twelve samples of polymers. These need to, as far as possible, be actual manufactured items, e.g. a piece of plastic guttering and a plastic bag, rather than samples from a kit. Candidates can then work in groups to discuss what properties the samples have which make them suitable for that purpose. Next, the materials can be identified and labelled. This can then lead on to what the names and descriptions mean and what processes the material has undergone in manufacture.

In rounding off the study of each class of materials, candidates can be invited to seek out, and, where possible, bring in to class, other examples of applications of the class of materials, and to identify them.

Physical properties

The following glossary identifies a wide range of properties. Candidates will be expected to **only study a selection of these** appropriate to their chosen case study. It would be difficult to maintain candidates' enthusiasm by simply working through the list week by week. It would be preferable to introduce the properties as they arise. A visit to the engineering department of a local manufacturer, college or university may provide an opportunity for candidates to see real materials testing in action.

Density:	Mass per unit volume (kg m^{-3}).
Tensile stress:	Tensile force/cross sectional area (N m^{-2}).
Tensile strain:	Change in length/original length (no units).
Elastic modulus:	Slope of the linear part of the stress-strain curve.
Young modulus, E:	Tensile stress/tensile strain (N m^{-2}). Candidates also need to recognise that the Young modulus can be applied for compression. They may also encounter the shear, bulk and torsional moduli but are not expected to define these.

Toughness:	The ability of a material to absorb energy and deform plastically without fracturing. The tougher the material, the more difficult it is for cracks to grow in it. Candidates need to find the toughness from the area under a force-extension graph. (See Bolton, p16).
Ductile:	Ductile materials (e.g. 20% mild steel) stretch more when under tension than brittle materials (e.g. 1% cast iron).
Hardness	A crude measure of strength. It is measured by pressing a pointed diamond or hardened steel ball into the material surface. For Brinell and Vickers tests, hardness = force/area of indentation (MPa.) The Rockwell scale is based on the depth rather than the area of indentation. Mohs' scale assessed the ability of **one** material to scratch another.
Ultimate tensile strength, σ_u:	Stress at which the material, loaded under tension, breaks (MPa.).
Electrical conductivity, σ:	Reciprocal of resistivity ρ. $\sigma = \frac{1}{\rho} = \frac{L}{RA}$ where: L is the length of a sample A is its cross-sectional area and R is its resistance Units: $\Omega^{-1} m^{-1}$ or siemen per unit length (S m^{-1}) 1 siemen (S) = 1 Ω^{-1}

Thermal conductivity λ:	$$\frac{\text{rate of flow of heat}}{\text{temperature gradient}}$$ where: temperature gradient = change in temperature per unit length along the direction of flow of heat Units: $Wm^{-1} k^{-1}$
Resistance to corrosion	
Linear thermal expansivity (coefficient of linear expansion, α)	$$\frac{\text{change in length}}{\text{original length} \times \text{change in temperature}}$$ Units: K^{-1}
Specific heat capacity, c:	$$\frac{\text{heat gained (or lost)}}{\text{mass} \times \text{change in temperature}}$$ Units: $J\ kg^{-1} K^{-1}$

Identifying objectives and constraints

A constraint is a feature of design that needs to be met at a specified level. An objective is a feature for which the best possible value is sought.

Ashby (1999) gives an example to illustrate the difference between the two: For a racing bicycle, mass needs to be minimised – this is an *objective*; cost must not exceed a particular budget – this is a *constraint*. A requirement for a shopping bicycle is that cost needs to be minimised – this is an *objective*; mass must not exceed a certain limit – this is a *constraint*.

Selection

Candidates need to learn to adopt a structured approach to materials selection. This is best reinforced by the study of case histories.

Having identified what properties are essential or desirable, candidates are expected to select using data.

Guidance on Assessment

Candidates need to carry out research for this unit, they need to be taught how to find, select and record the relevant information and its source. Coursework needs to include diagrams, tables, charts, graphs and calculations that are accurate to the correct degree. Candidates need to interpret their findings and draw conclusions.

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

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

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

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

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You need to use the full range of marks available to you. You need to award full marks in any strand for work which fully meets the criteria. This is work which is the best one could expect from candidates working at A2 level.

Only **one** mark per AO strand 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 AO strand.

The further guidance below amplifies the criteria in the *Assessment Evidence Grid* and will help the candidate to determine the appropriate mark to be awarded for each strand.

<table>
<tr><th colspan="3">Amplification of Criteria</th></tr>
<tr><th rowspan="4">AO1</th><th>Mark Band</th><th>Characteristics of the work one may expect to see at this mark band can be summarised as follows:</th></tr>
<tr><td>1</td><td>• Candidate demonstrates that they understand the differences in the structures of the different classes of materials listed;</td></tr>
<tr><td>2</td><td>• candidate demonstrates that they understand the differences in the structures and properties of the different classes of materials listed;</td></tr>
<tr><td>3</td><td>• candidate demonstrates that they can relate the differences in the properties of the different classes of materials listed to their structures;
Note: Research work should show candidate’s independent study (not cut & paste).</td></tr>
<tr><td rowspan="3">AO2</td><td>1</td><td>• Candidate outlines the purpose of an application and selects a reasonable material to fulfil this;</td></tr>
<tr><td>2</td><td>• candidate identifies fully the purpose of an application, suggests an alternative and makes a reasoned choice between them to fulfil the requirement;
• candidate carries out the required calculations given the appropriate equations;</td></tr>
<tr><td>3</td><td>• candidate identifies fully the purpose of an application, suggests a number of alternatives and fully justifies their choice between them to fulfil the requirement;
• candidate carries out the required calculations unaided.</td></tr>
<tr><td rowspan="3">AO3</td><td>1</td><td>• Candidate is able to carry out each of the experiments safely with some guidance, obtaining at least one set of results in each case;
• candidate demonstrates that they have some knowledge of the effect of work-hardening, annealing and tempering on the physical properties of one metal;</td></tr>
<tr><td>2</td><td>• candidate is able to carry out each of the experiments safely, obtaining full sets of results in each case and carrying out appropriate analysis of the results;
• candidate demonstrates that they know the effect of work-hardening, annealing and tempering on the physical properties of one metal;</td></tr>
<tr><td>3</td><td>• candidate is able to carry out each of the experiments safely, obtaining full sets of results in each case and carrying out appropriate analysis of the results; they are able to evaluate their experiments and draw meaningful conclusions from them;
• candidate demonstrates that they can explain the effect of work-hardening, annealing and tempering on the physical properties of one metal.</td></tr>
</table>

Resources

CD

Exploring Materials Education Pack Science Museum 1998 190 074 7103

Equipment

Young modulus apparatus, XPS 070 010, Scientific and Chemical £105 + wires;
Young modulus apparatus, c. £80 or c. £320, Phillip Harris;
Young modulus apparatus, XBV-711-V Griffin, c. £105;
Hardness of metals apparatus Phillip Harris, c. £20 + hand microscope c. £12.

Textbooks

Ashby M	*Material Selection in Mechanical Design*2nd ed	Butterworth Heinemann	075 064 579X

(Useful teacher's resource, but well beyond the level expected of candidates for this unit);

Ballard D *et al.*	*OCR A Level Applied Science*	Heinemann	978 0435692 12 4
Bolton W	*Materials for Engineering*	Newnes 2000 2nd ed	
Higgins AH	*Materials for the engineering technician*	Butterworth Heinemann	034 067 654X
Newey C & Wever G (eds.)	*Materials Principles and Practice*	Open University	075 060 3909

Websites

www.materials.ac.uk/resources

Unit G631: Electrons in Action

Guidance on Delivery

This unit will provide candidates with an opportunity to extend their knowledge and understanding of oxidation, reduction and redox equilibria. It will also introduce them to some applications of electrochemical reactions and the importance of these reactions with regard to energy changes. Many candidates are interested in issues of pollution and saving the environment. They will be able to expand their experience in these fields as they study the topics in this unit.

It is important that candidates learn and use the correct nomenclature and terminology. This can be introduced gradually and practised as the course progresses. Simple practical experiments, demonstrations and problem-solving exercises can be used to help strengthen understanding and maintain interest.

Most of the practical elements of the unit require only simple electrical apparatus, standard laboratory apparatus, carbon electrodes, a range of metals and metallic salts. A supply of commercial and storage cells will also be required. Before starting an experiment, candidates need to be encouraged to:

- have aims and objectives for the experiment;
- be organised;
- have tables ready to record observations and measurements;
- note measurements accurately;
- note the degree of accuracy of the apparatus and instruments used;
- note any conditions and materials that may affect results;
- identify hazards and prepare a risk assessment.

Electrochemical change

There are many simple test-tube experiments using displacement reactions that can be used to revise oxidation and reduction. These examples can be used to introduce transfer of electrons and then oxidation number. They can also be used to practise writing ionic half equations. Candidates need to identify:

- particles which are oxidised or reduced;
- the change in oxidation number and hence the number of electrons transferred;
- particles which act as oxidising agents and those which act as reducing agents.

A simple metal/metal ion voltaic cell will demonstrate the transfer of electrons around an external circuit. There may be time for candidates to make a simple battery from coins and lemon juice.

Some candidates may need to study many examples before they fully understand what is meant by an equilibrium reaction. They need to understand that there is a potential for the reaction to take place in a forwards or backwards direction and that the direction will depend on the conditions and reagents. A demonstration of the reactions in which zinc is oxidized to zinc ions by copper, and the one in which zinc ions are reduced to zinc by magnesium is a simple introduction to the reversible reaction:

$Zn(s) \rightleftharpoons Zn^{2+}(aq) + 2e^-$

Principles and applications of commercial cells

The fact that an equilibrium reaction exists between a metal and its ions introduces the existence of a half-cell and electrode potential.

Candidates need to understand that:

- potential cannot be measured;
- only potential difference can be measured;
- the polarity of the electrode will be determined by the identity of the other cell;
- values of standard electrode potentials are related to the standard hydrogen electrode.

Practical technique is important. Candidates need to become familiar with what happens if:

- the salt bridge is removed;
- crocodile clips are covered by the solution;
- the voltmeter is connected incorrectly;
- a high-resistance voltmeter is connected;
- the concentration of solution in one half-cell is changed.

They need to be encouraged to think of other factors such as size/position of electrode, which may or may not affect results.

A good understanding of chemical equilibria and how conditions can change potential will enable candidates to understand the need for a standard electrode and will help them to carry out tasks successfully.

The electrochemistry of primary and secondary cells is explained fully in most GCE Chemistry textbooks. Candidates should not have difficulty in finding information on commercial and rechargeable cells – there are some very good websites. However, candidates need to be encouraged to be selective when recording and presenting data.

Candidates could be asked to list storage cells with which they are already familiar. A survey could be carried out on types of cells purchased by a group of people, such as the class, or family and friends. The survey could be developed to find out about the use of each type; hours of use per day; cost per hour; voltage; total energy output etc. Some of this information could be used to compare costs and efficiency. All points in sub-section 3.12.2 need to be covered as this topic forms a large part of Task AO2.

Electrolysis and the extraction of metals

Most of the terminology should be familiar.

Candidates need to know that:

- electrons, from an external source, are used to produce a chemical change;
- ions need to be able to move through the electrolyte;
- positive ions move towards the negative electrode;
- when two different metal ions are present, the metal ions with the more positive potential are most likely to be discharged;
- the preferential discharge of an ion can be affected by its concentration;
- sometimes metal ions react with the electrodes (see extraction of sodium);
- the amount of product formed during electrolysis is determined by the amount of electricity passed around the circuit and the number of electrons involved in the reaction at the electrode;
- the unit of charge is the coulomb; coulombs = amps x seconds;
- 96 500 coulombs is the charge carried by one mole of electrons or one mole of singly charged ions.

Simple experiments to investigate copper plating should provide an opportunity for candidates to practise their technique, obtain results and carry out calculations. Candidates need to be encouraged to discuss ideas and to interpret results.

The industrial manufacture of metals such as aluminium and sodium covers most of the electrochemistry required and illustrates how simple experiments are developed to give a good rate of production while conserving energy and maintaining safety.

Many GCE Chemistry/Physics textbooks provide data on annual production and give examples on how to calculate the amount of electricity used.

Candidates need to:

- check that they have studied all points in the specification;
- select appropriate material;
- use their own words when writing coursework.

The practical experiment for producing pure copper forms the basis for the second strand of the task for AO3. It needs to be developed in order to meet all the criteria for a high mark. Some research into electroplating may be useful.

Fuel Cells

After studying the previous topics and realising the importance of recycling storage cells, the class could be asked to debate the question ‘Do we have an energy crisis?’ Candidates may have already discovered information about fuel cells when researching portable batteries and they will introduce the topic. It needs to be emphasised that hydrogen is not the only type of fuel used in these cells. Candidates need to research all points in this sub-section so that they can fulfil all the criteria for AO2.

Guidance on Assessment

Candidates need to carry out research for this unit, they need to be taught how to find, select and record the relevant information and its source. Coursework needs to include diagrams, tables, charts, graphs and calculations that are accurate to the correct degree. Candidates need to interpret their findings and draw conclusions.

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

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

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

You need to mark each portfolio according to the assessment objectives and content requirements in the *Assessment Evidence Grid* (Appendix B).

The information on this *grid* will eventually be transferred onto a *Unit Recording Sheet* to be attached to the front of each candidate's piece of work at the point when the work is submitted for moderation. A *Coursework Administration Pack* will be supplied, containing all relevant *Unit Recording Sheets*. Where marking for this unit has been carried out by more than **one** teacher in a centre, there must be a process of internal standardisation carried out to ensure that there is a consistent application of the criteria as laid down in the *Assessment Evidence Grids*.

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

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

You use your professional judgement to determine which descriptor in a strand best suits the individual candidate's work and from the range of marks available within that particular mark band, you circle the mark that best fits the work. You then record this mark (or sum of marks if there is more than one row for that particular assessment objective) in the column headed Mark.

You need to use the full range of marks available to you. You need to award full marks in any strand for work which fully meets the criteria. This is work which is the best one could expect from candidates working at A2 level.

Only **one** mark per AO strand 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 AO strand.

The further guidance below amplifies the criteria in the Assessment Evidence Grid and will help candidate to determine the appropriate mark to be awarded for each strand.

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO1	**1**	• Report to demonstrate the applications of electrochemical changes, including clear, correctly labelled diagrams and correct terminology with evidence of corrected punctuation and grammar; • portfolio demonstrates a basic understanding of redox reactions with appropriate examples; • some research has been done, but selection and presentation is limited;
	2	• report demonstrates applications of electrochemical changes in the production of primary cells, secondary cells, fuel cells and extraction of metals, including clear, correctly labelled diagrams of each and spelling, punctuation and grammar mainly used correctly; • portfolio demonstrates a knowledge and understanding of most of the redox reactions involved; the conditions required with explanations; scientific terms and conventions have been used; • research into each application has been done and relevant information has been selected and presented clearly and logically in the candidate's own words with sources credited;
	3	• report demonstrates applications of electrochemical changes in the production of primary cells, secondary cells, fuel cells and extraction of metals, including clear, correctly labelled diagrams of each and correct use of spelling, punctuation and grammar throughout; • the work demonstrates a thorough knowledge and understanding of all the redox reactions involved and the conditions required, with explanations, scientific terms and conventions have been used correctly and a wide range of research into each application has been done and relevant information has been selected; • the report is clear, logical, includes an evaluation and is expressed in the candidate's own words with sources credited.

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO2	**1**	• Examples of cells are described; there is only limited comparison and evaluation as outlined in the assessment grid; • the candidate has carried out straightforward calculations involving emf of cells and quantity of charge; some data has been recorded to compare the efficiency of batteries and calculations of efficiency have been attempted;
	2	• examples of each type of cell are described in detail; valid comparisons and evaluations have been made as outlined in the assessment grid; • candidate has carried out calculations involving emf of cells; quantity of charge and mass of product; data has been recorded to compare the efficiency of batteries; calculations of efficiency have been made and the correct solutions obtained;
	3	• examples of each type of cell are described accurately and in detail and valid comparisons have been made and detailed evaluations presented, as outlined in the assessment grid; • candidate has carried out calculations involving emf of cells; quantity of charge and mass of product; data has been recorded to compare more than **one** aspect of efficiency of batteries; calculations of efficiency have been made and the correct solutions obtained to an appropriate degree of accuracy.

<table>
<tr><th>AO</th><th>Mark Band</th><th>Characteristics of the work one may expect to see at this mark band can be summarised as follows:</th></tr>
<tr><td rowspan="3">AO3</td><td>1</td><td>• Candidate has used a risk assessment in each activity, carried out the experiment using a satisfactory practical technique and appropriate apparatus and changed the conditions of each experiment to obtain sets of results for measurement of emf and for the measurement of the mass of copper plate;
• relevant observations and measurements from the above experiments have been recorded; the data has been displayed appropriately, with help;
• candidate has recorded units accurately; made calculations and attempted to interpret the results by considering practical technique and the principles of electrochemistry;</td></tr>
<tr><td>2</td><td>• candidate has carried out risk assessments consistent with COSHH guidelines before each activity and carried out the experiment using a good practical technique and the correct apparatus;
• where appropriate, candidate has repeated measurements and averages have been calculated; the candidate has worked with an appropriate degree of accuracy;
• relevant observations and measurements from the above experiments have been recorded and the data has been displayed accurately, without help; results have been displayed accurately in a range of ways;
• the candidate has recorded units accurately; made calculations; drawn basic conclusions; interpreted the results by considering practical technique and the principles of electrochemistry;</td></tr>
<tr><td>3</td><td>• candidate has carried out detailed risk assessments consistent with COSHH guidelines before each activity;
• where appropriate, candidate has repeated measurements and averages have been calculated; the candidate has worked with an appropriate degree of accuracy;
• relevant observations and measurements from the above experiments have been recorded and the data has been displayed accurately, without help; results have been displayed accurately in a range of ways;
• candidate has recorded units accurately; made calculations; drawn conclusions; interpreted the results by considering practical technique and the principles of electrochemistry.</td></tr>
</table>

Resources

CD-ROM

Aluminium a Modern Metal, Aluminium Federation; and the accompanying student information booklet

CD Magic of Metals, schools education pack, Dr Ray Oliver; Non-Ferrous Alliance 2004, available from the Aluminium Federation

Textbooks

Independent Learning Project for Advanced Chemistry (ILPAC) 2nd Ed

	Book 4: s-Block Elements	John Murray	071 955 334 2
	Book 7: Equilibrium III Redox Reactions	John Murray	071 955 337 7

Ballard D *et al.*	*OCR A Level Applied Science*	Heinemann	978 0435692 12 4
Lister T & Renshaw J	*Understanding Chemistry for A Level*	Stanley Thornes	074 870 216 4
University of Bath	*Science 16-19 Chemistry*	Nelson	017 448 236 1
University of York Science Group	*Salters Advanced Chemistry: Storyline*	Heinemann	043 563 1063
	Chemistry in Context Laboratory Manual and Study Guide	Nelson	017 448 1640

Videos

Electrochemistry ESSO
Industrial Chemistry for Colleges and Schools RSC

Websites

These sites have very useful information about electrochemical cells:

http://www.howstuffworks.com/
http://www.fuelcells.org
http://www.rbrc.org
http://www.ausetute.com.au/
http://www.valence.com/BatteryEducation.asp

Unit G632: The Mind and the Brain

Guidance on Delivery

The intention is that this unit will provide candidates with an introduction to how the brain works, the methods employed in investigating brain function and applications of this knowledge to a variety of academic and clinical areas. Neuroscience encompasses many disciplines and this unit introduces issues in philosophy, physiology, psychology and medicine relevant to the modern study of mind and brain. Many of these issues feature in the news and are the subject of popular science programmes, and candidates need to intelligently debate important topics.

Sub-section 3.13.1 *The mind, stress and illness* investigates the relationship between mind, stress and disease and explores the extent to which mind is linked to physical illness. Once candidates have learned about the stress responses, including the way in which the brain communicates with the immune system, they can debate whether stress is implicated in illnesses such as cancer and explore possible mechanisms. Recent developments have allowed us to explore the complex interaction between nervous and immune systems. Chemicals produced by immune cells stimulate parts of the brain; in turn, the immune system can be regulated by brain chemicals which also influence behaviour. Disruption of this mechanism has been implicated in both acute (short-term) and chronic (long-term) diseases. Candidates need to explore this, and other stress responses, and consider how illnesses such as heart disease and cancer develop and how psychological factors might input into these disorders.

Psychological factors such as stress and anxiety may also affect disease development indirectly by increasing the amount someone eats, smokes and drinks. Candidates need to learn how knowledge of biological mechanisms and psychological states and behaviours is integrated and applied in preventative-stress management and disease-intervention programmes.

Sub-section 3.13.2 *Exploration of the healthy and the damaged brain* concentrates on the basics of brain function and what happens when things go wrong. This provides the groundwork for later sub-sections of this unit and it is vital that candidates understand nerve-cell function and events at the synaptic junction, and that they grasp topics such as memory neurobiology and nervous-immune-system interaction.

Candidates need to study normal brain function and consider what happens when things go wrong, with a focus on frontal-lobe dysfunction. They also need to study examples of chemical systems in the brain, applying that knowledge to models of how **two** common drugs, Cocaine and Prozac, exert their effects on mind and brain.

Certain diseases and conditions have severe consequences for the brain, with profound and sometimes irreversible effects on cognition, mind and behaviour. Candidates need to explore the nature of Alzheimer's disease and Huntington's disease, both of which cause degeneration of brain tissue. They need to consider how these illnesses are currently treated and how they may be treated in the future. Schizophrenia, a profound disturbance of perception, mood and thought, also radically alters sense of self and mind. Candidates also need to learn about the various symptoms of schizophrenia, its likely causes and how the illness is treated.

Sub-section 3.13.3 *Methods and ethical issues in brain research* addresses methods and ethics in the study of mind and brain. Once clear on these scientific methods, candidates need to assess the successes of these technologies and look at the moral and ethical issues that they raise. This will prepare them for the assessed work that they need to complete. Candidates need to understand how to apply existing techniques to new questions and think creatively about new approaches. They need to study a variety of methods employed in neuroscience.

Candidates need to write a review of these methods, identifying strengths and weaknesses before studying a prepared account of an experimental protocol in neuroscience. They need to compose a critical evaluation of the methods employed and formulate an alternative experimental protocol with methods that they judge to be more appropriate, considering ethical issues in the process.

Sub-section 3.13.4 *Everyday cognition* addresses the problems in conceptualising mind and consciousness, and the relationship between consciousness and cognition in people with and without brain damage. Determining the nature of consciousness, and understanding how subjective experiences of mind arise from the activity of nerve cells, is a fundamental question in philosophy and neuroscience. Whilst biological explanations of mind and consciousness are important, many conceptual and philosophical issues, which inevitably arise from their investigation, also need to be addressed. Candidates will consider issues such as the distinction between mind and consciousness, how we determine the point at which an organism becomes conscious, and whether mind and consciousness arise solely from brain mechanisms. Many researchers view mechanisms such as learning, memory, perception and attention as cognitive components of consciousness. Our understanding of learning and memory processes has significantly increased over the past decade. Candidates need to consider how these processes occur in the brain, at a neural level and at a molecular level, and how knowledge of these mechanisms is being practically applied.

The Mind, Stress and Illness

There are many articles written for the layperson on the relationship between stress and illness, however, candidates need to be encouraged to explore articles with a scientific basis. There are well-written articles in recent issues of journals such as *Scientific American* and *New Scientist*. Once familiar with the complexity of the stress response and the relationship between nervous and immune systems, the complexity of the cancer process can be emphasised. There are a variety of Internet resources which illustrate the biology of cancer and the course taken by various forms of the illness. Candidates need to understand that the work to-date linking stress and cancer is fraught with methodological problems.

Exploration of the healthy and the damaged brain

It is envisaged that, for teaching purposes, this sub-section will be integrated with sub-section 3.13.3 *Methods and ethical issues in brain research.* Material here would benefit from conventional delivery, supplemented by anatomical models, video/DVD and the content of several Internet websites (see *References*). These websites offer superb *Flash* and *Shockwave* animations to help consolidate processes such as the action potential and synaptic transmission. In addition, candidates have the opportunity to develop their familiarity with spreadsheets and statistical packages. When exploring frontal-lobe function, candidates can make their own version of the Wisconsin Card-Sorting Test and explore how it is used in assessing frontal-lobe information processing. Candidates need to be aware of the variety of approaches to explaining disorders such as schizophrenia and need to refer to balanced documents such as review papers from the *British Medical Journal*.

Methods and ethical issues in brain research

This material will ideally be integrated with that from other sub-sections of this unit, particularly sub-section 3.13.2 *Exploration of the healthy and the damaged brain*, e.g. fMRI can be introduced when studying brain areas and specific cognitive functions. It is essential that candidates are aware of the ethical issues associated with each technique (details of suitable websites are given in *References* at the end of this section). These issues will be more apparent for techniques such as foetal brain-tissue grafting and stem-cell therapy than for techniques such as brain scanning. However, candidates need to be aware of the ethics of making predictions about behaviour based on findings from such scanning techniques.

Everyday cognition

Candidates need to understand that, before a particular mental function is investigated, a clear idea of exactly what it is being measured is required. Hence, exploring consciousness is contingent on conceptualising and defining what consciousness is. In this sub-section, candidates address philosophical concerns in the study of mind and brain. This will generate a great amount of class discussion as candidates consider issues such as the emergence of mind (when does mind develop?) and altered states of consciousness (how do drug-induced states differ biologically and phenomenologically from 'normal' consciousness?). Candidates also explore the neurobiological basis of memory, investigating how different forms of amnesia result from impairment to different parts of the memory system, and the techniques developed to circumvent these problems. After studying this sub-section, it is important that candidates are able to apply the knowledge that they have gained.

Whilst this unit requires learning a lot of factual information, there is plenty of scope to *apply* that knowledge and much room for debate. Debate and the practical work need to consolidate knowledge of the various methods employed and the importance of ethics in researching mind and brain, particularly with regard to the new- and evolving-technologies in neuroscience.

Guidance on Assessment

Candidates need to carry out research for this unit; they need to be taught how to find and select the relevant correct information and be aware of the various types of material available. Candidates need to demonstrate analysis and evaluation and need to be taught these skills if they are to achieve the higher marks.

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

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

It needs to be stressed that you determine only the *mark* for a candidate’s portfolio evidence and not the *grade* which will be determined by OCR.

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

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You use your professional judgement to determine which descriptor in a strand best suits the individual candidate's work and from the range of marks available within that particular mark band, you circle the mark that best fits the work. You then record this mark (or sum of marks if there is more than one row for that particular assessment objective) in the column headed *Mark*.

You need to use the full range of marks available to you. You need to award full marks in any strand for work which fully meets the criteria. This is work which is the best one could expect from candidates working at A2 level.

Only **one** mark per AO strand will be entered (although this may be the sum from several rows – **one** mark per row – for that particular AO strand). The final mark for the candidate is out of a total of **50** and is found by totalling the marks for each AO strand.

The further guidance below clarifies the criteria in the *Assessment Evidence Grid* and will help the candidate to determine the appropriate mark to be awarded for each strand.

<table>
<tr><th colspan="3">Amplification of Criteria</th></tr>
<tr><th>AO</th><th>Mark Band</th><th>Characteristics of the work one may expect to see at this mark band can be summarised as follows:</th></tr>
<tr><td rowspan="3">AO1</td><td>1</td><td>• Candidate produces an information pack consisting of two sets of fact sheets which show knowledge and understanding of sub-sections 3.13.1 The mind, stress and illness and 3.13.2 Exploration of the healthy and the damaged brain;
• some scientific terminology is used, generally correctly;
• candidate may have been guided to the most relevant sources and used these appropriately;
• sources may be of one type only and the candidate shows limited understanding of the material collected;</td></tr>
<tr><td>2</td><td>• candidate produces an information pack consisting of two sets of research which show a detailed knowledge and understanding of sub-sections 3.13.1 The mind, stress and illness and 3.13.2 Exploration of the healthy and the damaged brain;
• work presented shows suitable selection of information;
• they may have used clear diagrams to help and there are few errors present in the explanation of the principles;
• research is comprehensive using several different types of information;
• candidate has been selective in their use of sources, showing an understanding of the need to evaluate the quality of the information;
• scientific terminology is generally used well when explaining information employed in studying the mind and brain;</td></tr>
<tr><td>3</td><td>• candidate produces work which shows thorough knowledge and understanding of sub-sections 3.13.1 The mind, stress and illness and 3.13.2 Exploration of the healthy and the damaged brain;
• candidate has shown complete understanding of the content of the relevant sections;
• language is fluent and scientific terminology is accurate and used consistently;
• a wide variety of sources are selected to demonstrate the variety of opinion and assessed for relevance and truth;
• candidate has been able to set out the work logically with limited help and shown suitable selection of relevant material.</td></tr>
</table>

AO	Mark Band	Characteristics of the work one may expect to see at this mark band can be summarised as follows:
AO2	1	• Candidate has struggled with the academic facts pertaining to scientific methods and techniques employed in studying the mind and brain, and some factual errors are likely in the work; • they have acknowledged basic ethical issues; • candidate has identified basic problems with the prepared experimental protocol and highlighted arising ethical issues; • work shows research or practical investigations into statistical evidence on the selected topic with evidence that basic calculations have been correctly completed;
	2	• candidate has chosen relevant examples of methods used in the experimental **and** clinical study of the mind and brain, and explained the principles well; • they have provided a clear and logical account of prevailing ethical issues; • candidate has shown a clear understanding of the problems with the experimental protocol employed, and arising ethical issues; • work shows research into statistical evidence from a number of sources or practical investigations with evidence that calculations have been correctly completed and recorded;
	3	• candidate has selected a number of methods used in the experimental **and** clinical study of the mind and brain, explained the principles well and completed suitable evaluation; • work is clearly and logically selected and presented; • a comprehensive account is given of the conceptual, moral and ethical issues with different methods and techniques; • candidate has identified conceptual and ethical problems and inappropriate methods where relevant; • work reflects detailed coverage of sub-section 3.13.3 *Methods and ethical issues in brain research*; • all points are backed up with referenced evidence with only minor errors evident in interpretation; • work shows detailed research into statistical evidence on the selected topic with evidence that a selection of sources have been consulted with some evidence of statistical analysis.

AO	Mark Band	Characteristics of the work one may expect to see at this mark band can be summarised as follows:
AO3	1	• Candidate has carried out a simple experiment to investigate a particular cognitive function; • candidate has included evidence of research generally using correct punctuation and grammar with referencing of sources used; • suitable risk assessments need to be followed; • there is basic understanding of how to address a research problem and a consideration of some ethical issues; • data collected is clearly presented and correctly plotted and there is clear evidence of an explanation of the results obtained; • candidate will show some processing of data; • there is a simple evaluation;
	2	• candidate has designed and carried out a simple experiment which demonstrates clear conceptualisation of the issue at hand and a consideration of key ethical issues; suitable risk assessments are produced and followed; • candidate has included evidence of selected research generally using correct punctuation and grammar with suitable referencing of sources used; • evidence of the planning and completion of the chosen research problem/case study on memory; • data collection is precise and presented using a variety of methods; • candidate shows processing of data; • results are interpreted reliably with basic assumptions drawn and an attempt made to explain results in terms of underlying brain mechanisms; • there is an understanding of design limitations and how the work could be improved upon;
	3	• candidate has produced and carried out a sound experimental design which attempts to thoroughly investigate the cognitive function; • suitable risk assessments are developed, used and evaluated; • candidate has demonstrated a clear conceptual and ethical understanding of the issues at hand and independently chosen appropriate measures for their investigation; • candidate has included evidence of selected and detailed research using correct punctuation and grammar with detailed referencing of all sources used; • suitable justification of their work is included; • data collection is thorough, accurate and appropriately tabulated and visualised; • there are simple statistics such as means and standard deviations are evident as well as rates and graphs; • candidate will collect sufficient data to complete simple statistics on the results; • results are fully explained and reference made to likely underlying brain mechanisms where appropriate; • there is a thorough understanding of design constraints.

Resources

Organisations

British Association For Psychopharmacology
36 Cambridge Place, Hills Road, Cambridge CB2 1NS
http://www.bap.org.uk/ Tel: 01223 358 395

British Neuroscience Association
The Sherrington Buildings, Ashton Street, Liverpool L69 3GE
http://www.bna.org.uk/ Tel: 0151 794 4943

The British Psychological Society
St Andrews House, 48 Princess Road East, Leicester, LE1 7DR
http://www.bps.org.uk/index.cfm Tel: 0116 254 9568

Headway Brain Injury Association
Foster Drive, Mansfield Road, Nottingham NG5 3FJ
http://www.headway.org.uk/ Tel: 0115 967 9669

International Stress Management Association
PO Box 348, Waltham Cross, EN8 8ZL
http://www.isma.org.uk/ Tel: 0700 078 0430

Rethink (National Schizophrenia Fellowship)
30 Tabernacle Street, London EC2A 4DD
http://www.bna.org.uk/ Tel: 020 7330 9100

Publications

Scientific American (2002). *The Hidden Mind* Special Issue.

Scientific American (2003). *Better Brains* Special Issue. Oct.

Scientific American (2004). *Mind Special* Issue #1.

The Society For Neuroscience (20002) Brain *Facts – A Primer on The Brain and Nervous System*
ISBN: 091 611 000 1

Textbooks

Ballard D *et al.*	*OCR A Level Applied Science*	Heinemann	978 0435692 12 4
Damasio A	*Descartes' Error*	Papermac (1996)	033 365 656 3
Frith C	*Schizophrenia: A very short introduction*	OUP (2003)	019 280 221 6
Goldberg E	*The Executive Brain: The frontal lobes & the civilised mind*	OUP (2002)	019 556 307 X
Marmot M & Stansfield S	*Stress & The Heart: Psychosocial pathways to coronary heart disease*	British Medical Journal Books (2001)	072 791 277 1
Pierce HJ	*The Owner's Manual for the Brain: Everyday applications from mind-brain research*.	Natl Book Network (1994)	096 363 891 2
Pinker S	*The Blank Slate: The modern denial of human nature*	Penguin Press (2003)	014 027 605 X
Ramachandran VS & Blakeslee S	*Phantoms In The Brain: Human nature and the architecture of the mind*	Fourth Estate (1999)	185 702 895 3
Schwartz JM & Begley S	*The Mind & The Brain*	Harper Collins (2003)	006 098 847 9
Smith-Churchland	*Brain-Wise: Studies in neurophilosophy*	Bradford Book (2002)	026 253 200 X

Websites

Everyday Cognition

Consciousness & The Brain: Annotated Bibliography
http://home.earthlink.net/~dravita/

Neuropsychological Assessment & Resources
http://www.neuropsychologycentral.com/

Overview & Applications of Artificial Intelligence -
http://www.aaai.org/Pathfinder/html/overview.html

Philosophy of Mind
http://www.artsci.wustl.edu/~philos/MindDict/

Exploration of The Healthy and Damaged Brain

3-D Brain Anatomy
www.bbc.co.uk/science/humanbody/body/interactives/organs/brainmap/index.shtml

Central Nervous System Images
http://medlib.med.utah.edu/kw/sol/sss/subj2.html

Club Drugs
http://www.clubdrugs.org/

Mental Health
http://www.emental-health.com/

National Institute For Neurological Disorders & Stroke-Disorders
http://www.ninds.nih.gov/health_and_medical/disorder_index.htm

Neurotransmission Animation
http://www.brainexplorer.org/neurological_control/Neurological_Neurotransmission.shtml#

Phineas Gage Information Page
http://www.deakin.edu.au/hbs/GAGEPAGE/

Society For Neuroscience Brain Briefings
http://web.sfn.org/content/Publications/BrainBriefings/index.html

Methods and Ethical Issues In Brain Research

Brain Scans That Spy On The Senses
http://www.hhmi.org/senses/e110.html

Probe The Brain
http://www.pbs.org/wgbh/nova/mind/probe.html

Scanning The Brain
http://www.pbs.org/wnet/brain/scanning/index.html

The Whole Brain Atlas
http://www.med.harvard.edu/AANLIB/home.html

Unit G633: Ecology and Managing the Environment

Guidance on Delivery

This unit needs to draw on the scientific knowledge, skills and understanding provided by study of G620: *Science at work*, G621: *Analysis at work* and G622: *Monitoring the activity of the human body*. It should be possible to carry out this unit early in the second year, allowing the development of basic biological skills in an appropriate context, but this may depend on the seasonality of the ecosystem studied. The ecological concepts studied and the manipulation of ecological information and data, much of which is objective, although it can also be subjective or emotive, will build on the knowledge, understanding and evaluative skills from KS4 Science, in GCSE Science or Applied Science.

This unit focuses on the principles of ecology – the relationships of organisms with their biological and physical environment. Candidates use a range of ecological methods to examine and make measurements of **one** ecosystem in detail and apply these principles to their findings. It is suggested that candidates review and practise the techniques available before carrying out the study.

The remainder of this unit looks at the effects of environmental change and, with our knowledge of the effects of such changes, the methods employed to prevent or reduce any negative effects. The focus will range from simple candidate research to a more in-depth analysis and evaluation. Candidates need to be encouraged to take an objective view of scientific data, discarding any preconceived ideas. Many of the effects of environmental change throughout geological time have been positive and have been responsible for evolutionary change. Many candidates may also assume automatically that some of the most detrimental effects of change are caused by man, but need to appreciate that many, e.g. the production of greenhouse gases, may have more significant natural causes. Some of the effects of change may be unequivocal, while others are subject to debate.

The principle aim of the unit is to give candidates a sufficient grounding in this area to allow them to appraise critically the work of ecologists and the moral issues confronting them and to review how these problems might be addressed by professional biologists and society as a whole.

Candidates also need to consider the varied reasons for managing ecosystems, from biological and economic reasons to more moral and ethical considerations.

The success of this unit will depend on the availability of up-to-date information and access to resources. Where centres anticipate that candidates will find difficulty in locating appropriate sources, case-study material may be substituted.

Investigating ecosystems

The investigation of the ecosystem comprises the major part of this sub-section, but it is essential for candidates to examine all the techniques available to the ecologist for making measurements within ecosystems before they can plan and carry out their investigation. The investigation itself, and subsequent analysis, needs to comprise just over one-third of the allotted time for this unit. With preliminary work, it will comprise around half the unit in total. The ecosystem selected, ideally, should be local to your centre, and sufficiently complex in terms of biodiversity to generate sufficient data and discussion. Ecosystems should be avoided where there is insufficient expertise to help candidates with identification of organisms. Marine environments are ideal because every animal phylum is represented and organisms are, in the main, relatively easy to identify, but the study of these may not be practical for many centres.

Candidates need to appreciate that in determining the types and numbers of organisms in an ecosystem, ecologists need to use a range of techniques to make careful and accurate observations and measurements, and quantify these where possible.

For the physical environment the following measurements need to be considered, although for the study proper, candidates will select those appropriate to use:

- temperature – using thermometers, data-loggers, and/or thermistors;
- water pH – using indicators, pH meters, and/or data-loggers;
- oxygen content – using oxygen electrodes, data-loggers, chemical techniques (such as the permanganate method);
- salinity – using density methods, conductivity, or titration;
- dissolved substances – using chemical methods, e.g. testing kits for nitrates, phosphates;
- pollutants – using indicator species for detecting pollutants, e.g. the Trent Biotic Index, the River Invertebrate Prediction and Classification System (RIVPACS);
- organic matter – using turbidity measurements;
- micro-organisms – using plating techniques;
- light intensity – using light meters, data-loggers.

The use of data-loggers demonstrates how ICT can be valuable in ecological research.

A range of methods is available to display ecological data, e.g. line graphs, bar graphs, histograms, kite diagrams, pictographs, pie graphs, rose diagrams and scattergraphs. Calculations and statistical tests, carried out by hand calculation, or using computers, are particularly useful in ecology and are necessary to determine whether differences in data are the result of chance. It needs to be emphasised, though, that the first time candidates use statistics, calculations need to be carried out manually.

Appropriate statistics can be used to:

- summarise data using descriptive statistics (mean, standard deviation);
- manipulate data, e.g. using Simpson's diversity index;
- test the validity of trends or differences in data using comparative statistics (correlation coefficient, chi-squared test or t-test).

The effects of change on ecosystems

It is important that candidates appreciate that not all environmental changes are man-made. They need to consider and examine natural change in the environment, e.g. from seasonal changes to volcanic eruptions. They also need to describe the changes that occur during an ecological succession. This could be accompanied by practical work, if time allows. A study of ecological successions in sand dunes (although the process is now complete in dune systems in the UK, the mature dunes still illustrate the process) could also comprise candidates' study of an ecosystem. Interesting alternatives include studies of the fermentation of lambic beers (enabling excellent applied comparisons) or of coprophagic fungi.

For the research aspect, candidates need to consult appropriate references to ensure that they get a balanced view of the problem. They need to apply the ecological principles first encountered in Key Stage 4, when examining: the effects of agricultural practice, habitation and greenhouse gases, e.g., in agricultural activity; the bioaccumulation of insecticides, e.g. DDT; inorganic nitrate and phosphate fertilisers causing eutrophication of natural waters. This could be extended to include the toxicity of fungicides or herbicides, e.g. dioxin impurities in 2,4-D. Natural processes leading to the build up of greenhouse gases need to be considered in detail by candidates, as well as the contribution from industrial emissions.

Investigating the management of ecosystems

To begin this sub-section, candidates need to consider the biological and economic reasons for preserving ecosystems, but then consider moral and ethical reasons, including intrinsic arguments. Ecological ethics are defined by the United Nations as the 'moral principles governing the human attitude towards the environment, and rules of conduct for environmental care and preservation'. It will be necessary to define, and have a preliminary discussion about, moral justification (is it simply 'right or wrong' to carry out activities without regard to ecosystems/preserve ecosystems?) and ethical concerns (reasons and justifications as to whether it is right or wrong), and intrinsic arguments, such as, is it acceptable to interfere with nature?

Discussion could be based on questions such as:

- Is it morally wrong to destroy a plant or animal species, or an ecosystem, regardless of whether such destruction has any consequences for human beings?
- Is the intrinsic value of non-human life dependent on the usefulness this life may have for human purposes?
- Do non-human organisms have 'rights' to exist? Should we think of animals and plants differently in this respect?

Examples to be considered could include:

- killing elephants for ivory;
- picking wild flowers;
- fishing;
- farming;
- building new houses;
- constructing new roads.

There is a wide range of options for candidates to study while investigating the management of ecosystems. Opportunities exist to study global initiatives, but ideally candidates need to experience ecological management first hand. Centres need to tailor this to local circumstances. Most local councils practise some form of environmental management, but it is also hoped that candidates will have the opportunity to visit managed areas such as National Parks, National Trust land, WWT and other reserves, county conservation trusts, wildlife parks, reservoirs, rivers, lakes and areas managed for fishing. It is also recommended that candidates meet and question one or more ecologists. Even the most urban environments offer opportunities for such liaison between professional ecologists/environmental managers and candidates.

Guidance on Assessment

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

You need to mark each portfolio according to the assessment objectives and content requirements in the *Assessment Evidence Grid* (Appendix B).

The information on this *grid* will eventually be transferred onto a *Unit Recording Sheet* to be attached to the front of each candidate's piece of work at the point when the work is submitted for moderation. A *Coursework Administration Pack* will be supplied, containing all relevant *Unit Recording Sheets*. Where marking for this unit has been carried out by more than **one** teacher in a centre, there must be a process of internal standardisation carried out to ensure that there is a consistent application of the criteria as laid down in the *Assessment Evidence Grids*.

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

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

You use your professional judgement to determine which descriptor in a strand best suits the individual candidate's work and from the range of marks available within that particular mark band, you circle the mark that best fits the work. You then record this mark (or sum of marks if there is more than one row for that particular assessment objective) in the column headed *Mark*.

You need to use the full range of marks available to you. You need to award full marks in any strand for work which fully meets the criteria. This is work which is the best one could expect from candidates working at A2 level.

Only **one** mark per AO strand will be entered (although this may be the sum from several rows – **one** mark per row – for that particular AO strand). The final mark for the candidate is out of a total of **50** and is found by totalling the marks for each AO strand.

The further guidance below amplifies the criteria in the *Assessment Evidence Grid* and will help the candidate to determine the appropriate mark to be awarded for each strand.

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO1	**1**	• Candidate produces evidence showing a knowledge of some of sub-section 3.14.2 *Effects of change on ecosystems* to link with the requirements of the task; • some scientific terminology is used, generally correctly; • using corrected spelling, punctuation and grammar; • candidate is guided to the most relevant information and use this correctly; • some research is done, with guidance, but understanding is limited; • descriptive work is presented clearly;
	2	• candidate produces evidence showing some detailed knowledge and understanding of most of sub-section 3.14.2 *Effects of change on ecosystems*; • scientific terminology is generally used well when explaining information; • candidate selects the most relevant information and uses it correctly, • generally using correct spelling, punctuation and grammar; • a suitable range of research is carried out and relevant information is selected and presented clearly and logically in candidate's own words with sources credited; • suitably detailed descriptive work on ecological selection is presented clearly and logically;
	3	• candidate produces evidence showing thorough knowledge and understanding of sub-section 3.14.2 *Effects of change on ecosystems* to reflect the requirements of the task; • language is fluent and scientific terminology is accurate and used consistently; • using correct spelling, punctuation and grammar throughout; • suitable comprehensive research is carried out, using a wide variety of sources, and suitable material is selected and used; • relevant information is selected and presented clearly and logically, with suitable evaluation and justification of the work produced; • relevant detailed descriptive work on ecological selection is presented clearly and logically with little help.

<table>
<tr><th colspan="3">Amplification of Criteria</th></tr>
<tr><th>AO</th><th>Mark Band</th><th>Characteristics of the work one may expect to see at this mark band can be summarised as follows:</th></tr>
<tr><td rowspan="3">AO2</td><td>1</td><td>• Candidate identifies adequately a variety of reasons for preserving ecosystems and species' diversity;
• candidate provides a description of methods available to preserve ecosystems and species' diversity, focusing on the requirements of sub-section 3.14.3 Investigation of the management of ecosystems carrying out, with guidance, a basic study and evaluation of methods used to manage one ecosystem;
• some basic straightforward calculations on ecological data are completed correctly, as identified in sub-section 3.14.1 Investigation of ecosystems;</td></tr>
<tr><td>2</td><td>candidate clearly identify and explain a variety of reasons for preserving ecosystems and species' diversity;
candidate provides a detailed description of methods available to preserve ecosystems and species' diversity focusing on the requirements in sub-section 3.14.1 Investigation of the management of ecosystems carrying out a detailed study and evaluation of methods used to manage one ecosystem;
some complex calculations on ecological data are completed correctly as identified in sub-section 3.14.1 Investigation of ecosystems;</td></tr>
<tr><td>3</td><td>• candidate identify fully, and explain fully, a variety of reasons for preserving ecosystems and species' diversity;
• candidate provides a detailed description of a range of methods available to do this, focusing on the requirements in sub-section 3.14.1 Investigation of the management of ecosystems carrying out a detailed study and evaluation of a range of methods used to manage one ecosystem with detailed explanation and evaluation;
• complex calculations on ecological data, involving statistical analysis, are completed correctly as identified in sub-section 3.14.1 Investigation of ecosystems with correct solutions to an appropriate degree of accuracy showing an understanding of the significance of the outcomes.</td></tr>
</table>

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO3	**1**	• Candidate uses and produces risk assessments and carries out any practical work using a range of techniques and equipment; • relevant observations and measurements from the work are recorded; the data are displayed appropriately, with help; • there is some interpretation, a conclusion and simple evaluation;
	2	• candidate uses and produces risk assessments consistent with COSHH guidelines and carries out any practical work using a range of techniques and equipment, using good practical technique; • repeated measurements are carried out where appropriate; • relevant observations and measurements from the work are recorded; • the data are displayed accurately in a range of ways; • there is an interpretation of all results, conclusions and relevant evaluation;
	3	• candidate, with little guidance, uses and produces detailed risk assessments consistent with COSHH guidelines, and carries out practical work competently using a range of techniques and equipment, consistently using good practical technique; • repeated measurements are carried out, where appropriate, with suitable explanations; • detailed observations and accurate measurements are recorded consistently; • the data are displayed logically and accurately in a range of ways; • there is a full interpretation of all results, conclusions and relevant justification and evaluation.

Resources

Textbooks

Allen D & Williams G	*Collins Advanced Modular Sciences: Applied Ecology*	Collins Educational (2001)	000 327 741 0
Ballard D *et al.*	*OCR A Level Applied Science*	Heinemann	978 0435692 12 4
Chapman JL & Reiss MJ	*Ecology. Principles and Applications*	CUP (1992)	052 138 951 8
Dresner S	*The Principles of Sustainability*	Earthscan (2002)	185 383 842 X
Hayward G	*Applied Ecology*	Nelson Thornes (1992)	017 448 187 X
Odum EP	*Fundamentals of Ecology*	Saunders College Publishing (1971)	072 166 941 7
Topfer K	*Global Environment Outlook 3: Past, Present and Future Perspectives*	Earthscan (2002)	185 383 845 4

Websites

Bioremediation

Arizona State University
http://photoscience.la.asu.edu/photosyn/courses/BIO_343/lecture/bioremed.html

National Agricultural Library (plus links to other sites)
http://www.nal.usda.gov/bic/Biorem/biorem.htm

US Geological Survey
http://water.usgs.gov/wid/html/bioremed.html

Carbon sinks

BBC News Sci/Tech
http://news.bbc.co.uk/1/hi/sci/tech/1426453.stm

Environmental Literacy Council
http://www.enviroliteracy.org/article.php/48.html

Ethics and the environment
http://www.ul.ie/~philos/vol1/paper4.html

National Geographic
http://news.nationalgeographic.com/news/2001/06/0621_carbonsinks.html

Royal Forestry Society
http://www.rfs.org.uk/thirdlevel.asp?ThirdLevel=122&SecondLevel=67

General and environmental ethics

Environmental Literacy Council
http://www.enviroliteracy.org/

Food and Agriculture Organisation of the United Nations Biological Diversity in Food and Agriculture
http://www.fao.org/biodiversity/link_en.asp

United Nations
http://www.un.org/english

WWF – The Conservation Organisation
http://www.panda.org

Greenhouse gases
Climatic Research Unit

http://www.cru.uea.ac.uk/

Earth Science Australia
http://earthsci.org/teacher/basicgeol/change/change.html#Greenhouse

(US) Energy Information Administration
http://www.eia.doe.gov/oiaf/1605/gg98rpt/emission.html

World Resources Institute
http://climate.wri.org

Unit G634: Applications of Biotechnology

Guidance on Delivery

The intention is that this unit will provide candidates with an introduction to some of the applications of biotechnology. The unit focuses on **three** key areas:

Biotechnology is such a diverse subject that sub-sections 3.15.1 *The science of genetic engineering*, 3.15.2 *Use of recombinant DNA technology in medicine* and 3.15.3 *Production of genetically modified (GM) food plants*, concentrate on areas of work that are frequently in the news, and should allow candidates to intelligently join the debate.

Sub-section 3.15.1 *The science of genetic engineering* outlines the basic scientific background to recombinant DNA technology. Sub-section 3.15.2 *Use of recombinant DNA technology in medicine* is about the use of recombinant gene technology to treat current genetic diseases and produce novel proteins like insulin or human-growth hormone. Again, the science behind gene therapy, genetic testing and the production of bio-molecules needs to be clear in the minds of candidates, but is not the main focus of this sub-section. Sub-section 3.15.3 *Production of genetically modified (GM) food plants* is on the genetic manipulation of plants, another contentious area and the same applies here. Once in possession of the facts, candidates can enter the debate on legal constraints, problems with the environment and the clear benefits that this technology could provide to society.

Once clear on the technology, candidates need to assess the successes of these technologies and look at the moral and legal issues that they raise. It cannot be emphasised enough that candidates need to be in a position, after having been taught the bald facts, to formulate in their own minds what their feelings are for this technology. They then need to communicate this on paper or in presentation adequately.

Sub-section 3.15.4 *Enzyme Technology* concentrates on the established use of enzymes in industrial processes, including the production of beverages, an area with which candidates are likely to be familiar. Although candidates do need to know the theory behind this activity, primarily this is a practical sub-section and the emphasis needs to be on investigative work on the merits of fermenters and immobilisation. Candidates need to be given at least some freedom to come up with their own design (within the constraints of your centre's science equipment and budgets) and grapple with the problems in making new technology work.

Research will be a critical factor in the successful completion of this unit and it would be wise to collect useful articles and journals well before candidates start on this work. Candidates need access to a variety of quality resources from sources that reflect the full range of feeling in this area. If the academic science is taught in fairly conventional ways before candidates start to research the technology, the materials found will have more meaning and work will be more focused.

The science of genetic engineering

Although candidates need to have a clear idea as to the theory behind genetic engineering, this does not preclude a great deal of practical activities to aid the learning that needs to go on before the applications are tackled. Candidates could make their own models of DNA and protein synthesis to help the thought processes, and actually extract DNA from onion or kiwi fruit so that they can actually see it in action. Some investigation into the discovery of the structure of DNA may also be appropriate. Although expensive, the NCBE (National Centre for Biotechnology Education) kits that use restriction enzymes to cut up phage DNA come highly recommended (see *Resources* at the end of this section), and it is much easier to explain the process once candidates have seen it done. Electrophoresis is best taught this way. Candidates need careful supervision when doing this practical, since they are often not used to the levels of accuracy needed to be successful. A good split between practical and theory is sensible to keep motivation levels up, and it would probably pay off to test candidates on the material before moving on to the applications. After teaching this sub-section, it is vital that candidates are able to apply the knowledge that they have gained to the medical and agricultural applications they will face later on.

Using recombinant DNA technology in medicine

It is quite easy to get snowed under by the amount of information available in this area and the temptation for many candidates is to submit page after page of Internet resources with little analysis and comment. As far as possible, written work needs to be properly referenced and clear conclusions drawn from the material. The ideal is that all candidates will understand that every source may have a bias, and that they need to collect a range of views. Although able candidates may not need it, you may find it useful to prepare a resource box with a variety of different materials that candidates can access. Some candidates will need a few quality articles to get them started and the best place to begin would be the range of GCE textbooks dedicated to this area for example, references on page162 of *Applied Genetics 16-19* (Hayward) and on page 48 of *Microbiology and Biotechnology* (Lowrie & Wells). Once more confident, they could then move to more difficult material in journals like *Biological Science Review* and the *New Scientist*. You may find it helpful to supervise the initial research to ensure that candidates are focused on the criteria and collect only relevant information. A great deal of time needs to be spent on finding and deciphering information. Pooling information within a class would not be a problem as long as the labour is equally divided.

There is plenty of scope for debate in this unit and it is a good way of investigating the true feelings of the group to the technology. It is interesting to explore what they would do if placed in a situation where they would have to decide whether to use the technology to save a life. Hopefully, debate and research will lead all candidates to form at least a basic understanding of the morals and ethics in this area, with the best candidates able to justify their opinions with fluent argument backed with fact.

Production of genetically modified food plants

Much of what has been already said holds true for genetically modified plants as well. However, environmental concerns can be investigated more efficiently in this sub-section than any other. Since the public is so ‘anti’ genetically modified food, it would be easy to present quite a biased view. Candidates need to look at balanced documents that look at the facts, such as the Royal Society report, as well as material from pro- and anti- organisations and pressure groups. Although not required, practical work in this area is likely to supplement theory as before. It is possible to infect sunflowers with plasmids and micro-propagate food plants quite cheaply. Since, as a society, many are less and less aware of how food is produced, practical examples can only help.

Enzyme technology

Although this sub-section is integrated into the teaching of the other material, it could be taught as a discrete *unit* if required. It is **not** expected that candidates will have to come up with relevant strategies on their own. It would be acceptable to use existing methods found in the literature, and weaker candidates may have to be directed to this material. Some centres already have working fermenters available, but it would be useful if the investigative approach was retained and candidates try to make their own, using simple laboratory equipment. There is substantial opportunity to develop skills in ICT here, such as data logging and the use of spreadsheets. Data need not be laboriously plotted by hand, as long as candidates are able to explain what the software is doing.

Guidance on Assessment

It needs to be stressed that you determine only the *mark* for a candidate’s portfolio evidence and not the *grade* which will be determined by OCR.

You need to mark each portfolio according to the assessment objectives and content requirements in the *Assessment Evidence Grid* (Appendix B).

The information on this *grid* will eventually be transferred onto a *Unit Recording Sheet* to be attached to the front of each candidate’s piece of work at the point when the work is submitted for moderation. A *Coursework Administration Pack* will be supplied, containing all relevant *Unit Recording Sheets*. Where marking for this unit has been carried out by more than **one** teacher in a centre, there must be a process of internal standardisation carried out to ensure that there is a consistent application of the criteria as laid down in the *Assessment Evidence Grids*.

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

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

You use your professional judgement to determine which descriptor in a strand best suits the individual candidate's work and from the range of marks available within that particular mark band, you circle the mark that best fits the work. You then record this mark (or sum of marks if there is more than one row for that particular assessment objective) in the column headed *Mark*.

You need to use the full range of marks available to you. You need to award full marks in any strand for work which fully meets the criteria. This is work which is the best one could expect from candidates working at A2 level.

Only **one** mark per AO strand will be entered (although this may be the sum from several rows – **one** mark per row – for that particular AO strand). The final mark for the candidate is out of a total of **50** and is found by totalling the marks for each AO strand.

The further guidance below clarifies the criteria in the *Assessment Evidence Grid* and will help the candidate to determine the appropriate mark to be awarded for each strand.

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO1	**1**	• Candidate produces information which shows knowledge and understanding of sub-section 3.15.1 *The science of genetic engineering* and 3.15.2 *Use of recombinant DNA technology in medicine*; • some omissions are acceptable at this level but candidates aim to address the majority of the information listed by the bullet points; • some evidence of how material has been selected and used to provide an information document; • candidate shows evidence of research and an awareness of the legislation; • some scientific terminology is used, generally correctly; candidates may have been guided to the most relevant sources and used these appropriately; • evidence of corrected punctuation and grammar;
	2	• candidate produces information which shows detailed knowledge and understanding of sub-section 3.15.1 *The science of genetic engineering* and 3.15.2 *Use of recombinant DNA technology in medicine*; • candidate includes the majority of the information listed by the bullet points and shows evidence of selection of suitable factual data and suitable discussion of ethical and moral issues; • detailed evidence of how material has been selected and linked to the requirements of the set task – public information document; • candidate has carried out some of their own research into some of the topics listed with an understanding of legislation and control; • candidate has been selective in their use of sources, showing an understanding of the need to evaluate the quality of the information; • scientific terminology is generally used well when explaining gene technology; • evidence of correct punctuation and grammar;
	3	• candidate produces information which shows thorough knowledge and understanding of sub-section 3.15.1 *The science of genetic engineering* and 3.15.2 *Use of recombinant DNA technology in medicine*; • candidate addresses all of the information listed by the bullet points with clear evidence of appropriate detailed information being selected and logically presented for the public information booklets; • the work includes logical discussion of chosen topics linked to ethical and moral issues where appropriate; • candidate shows evidence of thorough research and an awareness and a clear understanding of the legislation and control; • language is fluent and scientific terminology is accurate and used consistently; • a wide variety of sources are selected to demonstrate the variety of opinion; • candidate is able to set out the work logically with limited help; • evidence of correct spelling, punctuation and grammar.

<table>
<tr><th colspan="3">Amplification of Criteria</th></tr>
<tr><th>AO</th><th>Mark Band</th><th>Characteristics of the work one may expect to see at this mark band can be summarised as follows:</th></tr>
<tr><td rowspan="3">AO2</td><td>1</td><td>Candidate produces suitable evidence to show they have understood some of the bullet points listed in sub-section 3.15.3 Production of genetically modified food plants and is aware of the effectiveness of the techniques used and provide a list of the benefits;
candidate, in addition, discusses the impact on society of production of genetically modified (GM) plants, there is limited evidence from research to support the findings;
candidate will demonstrate the completion of straight forward calculations either related to their research or to their practical investigations;
candidate has produced a simple analysis, possibly in tabular form of what they see are the rights and wrongs of this technology to society;
although some evidence of independent thought is evident, candidates rely on the published material for their views to a greater extent;
one piece of legislation is described, with no attempt at evaluation;</td></tr>
<tr><td>2</td><td>candidate shows clear evidence of evaluation of many of the bullet points listed in sub-section 3.15.3 Production of genetically modified food plants and they are able to explain some of the successes and failures of the technology and link them to the impact on society focussing on at least two specific examples;
all points are backed up with evidence with some errors evident in interpretation;
candidate will demonstrate the completion of straight forward and complex calculations either related to their research or to their practical investigations, limited assistance has been used;
several of the issues of society concerning this technology, again quoting clear examples;
two pieces of legislation are described and there is some evidence of evaluation;</td></tr>
<tr><td>3</td><td>candidate shows clear evidence of an understanding of all bullet points listed in sub-section 3.15.3 Production of genetically modified food plants and a thorough evaluation of the effectiveness and success of the techniques with limited help;
they are able to explain the successes and failures of the technology and justify their own opinion on the impact of society and potential for the future;
all points are backed up with referenced evidence with only minor errors evident in interpretation;
candidate will demonstrate the independent completion of complex calculations either related to their research or to their practical investigations;
candidate is able to assess the major issues facing society concerning this technology, again quoting clear examples and rank them for relative importance;
legislation is evaluated for how effective it is in controlling scientific activity.</td></tr>
</table>

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
AO3	**1**	• Candidate produces a basic plan and safely carries out an investigation into enzyme technology; • evidence of understanding some of the bullet points in sub-section 3.15.4 Enzyme technology is evident in the investigation; • candidate constructs a simple reactor and are able to produce and use an immobilised enzyme but need help to do it; • candidate uses a range of techniques and equipment; • data collected is correctly recorded and displayed – with help; • there is clear evidence of some interpretation and processing of results relating them to how enzymes work and enzyme immobilisation an explanation of the results obtained; • evidence of some evaluative work;
	2	• candidate produces a clear plan with little help and safely carry out an investigation into enzyme technology; • there is evidence that candidate is aware of the COSHH guidelines; • evidence of understanding of the majority of the bullet points in sub-section 3.15.4 Enzyme technology is evident in the investigation; • with support, candidate is able to produce a clear strategy to investigate the effect of temperature on the rate of reaction in the bioreactor and can describe the advantages of immobilised enzymes; • candidate's confidently uses a range of techniques and equipment in the majority of their work; • candidate produces evidence of the recording of relevant observations and measurements on both the bioreactor and the immobilised enzymes and data is clearly and accurately displayed; • some processing e.g. rates of reaction are correctly calculated and plotted; • conclusions show candidate is able to apply some of the theory on enzyme action to the results obtained; • basic evaluation included;

Amplification of Criteria		
AO	**Mark Band**	**Characteristics of the work one may expect to see at this mark band can be summarised as follows:**
	3	• candidate produces a clear and detailed plan and safely carry out an investigation into enzyme technology; • there is evidence of detailed risk assessments and that candidates are aware of the COSHH guidelines; • evidence of understanding the bullet points in sub-section 3.15.4 Enzyme technology is evident in the investigation and candidates produce a wide-ranging investigation into the effect of temperature on enzyme activity in immobilised enzyme systems; • planning is relevant with a good use of secondary sources to guide strategy; • candidate confidently uses a range of techniques and equipment with an explanation of why they are used; • repeats of experiments and adaptations of the plan are evident throughout; • candidate produces evidence of the recording of a detailed set of relevant observations and measurements on both the bioreactor and the immobilised enzymes with limited help; • all data is clearly and accurately displayed; • processing of results e.g. simple statistics such as means and standard deviations are evident as well as rates and graphs; • results are fully explained in terms of enzyme activity and work evaluated.

Resources

Organisations

Biotechnology and Biological Sciences Research Council (BBSRC)
Polaris House, North Star Avenue, Swindon, SN2 1UH
Tel: 01793 413200

National Centre for Biotechnology Education (NCBE)
School of Food Biosciences, The University of Reading, PO Box 226, Reading, RG6 6AP
Tel: 01189 873 743

Textbooks

Ballard D *et al.*	*OCR A Level Applied Science*	Heinemann	978 0435692 12 4
Boyle M	*Genes and Genetic Engineering* (AQA(B) Biology)	Collins	000 327 710 0
Chenn P	*Micro-organisms and Biotechnology*		071 957 509 5
Freeland P	*Microbes, Medicine and Commerce*	Hodder & Stoughton (1999)	034 073 103 6
Gregory J	*Applications of Genetics*	Cambridge Advanced Science	
Hayward G	*Applied Genetics 16-19*	Nelson-Thornes (1992)	
King T & Reiss M	*Practical Advanced Biology*		
Lowrie P & Wells S	*Microbiology and Biotechnology*	CUP (2000)	
Mannion K & Hudson T	*Microbes and Disease*	Harper Collins (2001)	000 327 742 9
Mannion K & Hudson T	*Microbes, Medicine and Biotechnology*	Collins	
Taylor J	*Micro-organisms and Biotechnology*	Bath Science (1990)	
Trevan MD	*Biotechnology: The Biological Principles*	John Wiley (1991)	

Websites

Select biotechnology link for gene technology and genetically modified organisms, range of articles and activities
http://www.agresearch.co.nz/scied/search/index.htm

Downloadable discussion documents on ethical issues
www.bbsrc.ac.uk/

Background information on Plant Biotechnology
www.biotechknowledge.monsanto.com/biotech/bbasics.nsf/index.html?OpenPage

Index of useful sites for biotechnology
www.biozone.co.uk/biolinks/BIOTECHNOLOGY.html

Introductory article on use of gene therapy to treat cystic fibrosis
www.cfgenetherapy.org.uk/

Comprehensive site – Browse
www.advisorybodies.doh.gov.uk/genetics/gtac/

Documents related to effect of GM trials on honey production
www.foe.co.uk/resource/briefings/bees_honey_gm_crops.html

Documents related to GM crops used as animal feed
www.foe.co.uk/resource/briefings/gm_crops_animal_feed.html

General site includes articles on GM foods
www.food.gov.uk/gmfoods

National Centre for Biotechnology Education – good for articles and supply of teaching resources including enzymes
www.ncbe.reading.ac.uk/

Article: Genetically modified plants for food
www.royalsoc.ac.uk/displaypagedoc.asp?id=7543

Article 'Code of practice on the provision of information relating to GM crops'
www-saps.plantsci.cam.ac.uk/articles/broad_code.htm

Unit G635: Working Waves

Guidance on Delivery

This unit focuses on some of the applications of electromagnetic waves which are most likely to be of interest to candidates. This is intended to allow sufficient time for these topics to be covered in as much depth as is appropriate at this level. However it is important that the content needs to be firmly rooted in the context of the electromagnetic spectrum as a whole, recognising the similarities and differences between electromagnetic and other types of waves.

Waves

Although it may be appropriate to introduce some of this sub-section as an introduction to this unit, other concepts need to be developed as they arise in the context of the applications. The features common to all waves include:

Repeating wave patterns

- repeating wave patterns
- speed
- wavelength
- frequency
- phase

In considering the features belonging to sound waves, but not others, candidates need to learn about

- transverse and longitudinal waves
- polarisation
- sine- and square wave shapes

The features unique to electromagnetic waves might be introduced as follows:

- discuss the electric field produced by a single charge, then by a pair of equal- and opposite- stationary charges;
- develop the idea that oscillating a pair of equal- and opposite-charges will produce oscillating electric fields;
- note that electric fields are detectable at a distance even if there is a vacuum between the source and the detector;
- there is a time delay between changes occurring at the source and reaching the detector; the signal travels at the speed of light; the oscillating field forms a wave between the source and detector;
- the oscillations can carry information encoded into them;
- changes in field can transmit energy, e.g. oscillations in radio antennae, light from the sun;
- a changing electric field always has an associated magnetic field at right angles, hence the term electromagnetic radiation;
- high frequencies are needed to create electromagnetic radiation electronically; radio waves were forecast by Maxwell before they could be produced;
- electromagnetic radiation is also produced by hot-bodies and by molecules, electrons in atoms and nuclei falling to lower energy levels and shedding excess energy as electromagnetic radiation;
- all electromagnetic radiation is part of the same family varying only in: – the order of magnitude of frequency, wavelength and amplitude; – the combinations of frequencies – monochromatic, line or continuous spectra;
- electromagnetic radiation may be formed by: – artificial means such as oscillating charges; – artificially excited atoms; – natural occurrences such as sunlight and radiation from uranium found in the earth.

Understanding of the electromagnetic spectrum needs to build on GCSE learning. Candidates need to be encouraged to consider whether dividing lines between the regions of the spectrum can be precisely drawn and, in particular, how the regions might be defined. Candidates need to recognise the regions of the electromagnetic spectrum and their similarities and differences of speed, wavelength, frequency and penetration of matter.

Candidates are expected to have carried out experiments on standing waves in strings or wires. For example if a signal from a signal generator is passed along a steel wire, and a large magnet place with its poles on either side of the wire, resonance can be demonstrated at the fundamental and harmonics. Nodes and antinodes can be observed and their separation measured. This effect can also be achieved using tuning forks, but the sustained oscillation produced by electromagnetically induced vibrations is easier to observe.

Students should be able to relate the length of wire and the separation of nodes and antinodes to wavelength and hence to calculate wavelength and wave velocity (given the driving frequency). Candidates should have observed the effects of changing driving frequency and wave velocity (string/wire tension), but knowledge of the mathematical relationship between tension and wave velocity is not required.

Ideally candidates will also have carried out experiment involving standing waves in pipes. At least they should be familiar with the patterns of nodes and antinodes for fundamental and harmonics for open and closed pipe ends, and use these to calculate wavelength. Stretch and challenge questions could relate the different patterns of harmonics to the quality of the note.

Thermal imaging and other applications of Infrared

Candidates need to understand that the term ‘hot-body’ radiation can be a misnomer and that radiation is emitted even by objects at cryogenic temperatures. More able candidates may be encouraged to think about the shape of the hot-body spectrum and research the elementary quantum mechanics concepts which can be used to explain it.

How optical fibres carry data

After an introduction identifying the limitations of traditional wire transmission of signals, learning about optical fibres could start with the question ‘why doesn’t the light leak out?’ The answer – that it is reflected – should then lead to the concept of total internal reflection and the conditions for this to occur. This lays the ground for introducing the traditional theory of refractive index, total internal reflection and critical angle.

Solid state lasers with wavelengths 0.8-0.9 μm, or 1.3-1.55 μm are commonly used in optical-fibre systems.

Modern communication systems – how cell-phones and broadband work

Learning about mobile phone technology could start with the questions:

- Why didn’t we have mobile phones years ago?
- Why were personal radios restricted to the emergency services and a restricted number of radio ‘hams’?

The answer – limitation in available frequencies – can then lead to an understanding of how multiplexing and cellular technologies overcome this problem and hence to more detailed considerations of the technologies themselves.

One activity which may capture the interest of candidates might be to investigate the variation of mobile phone signal strength using the meter built into a phone, including, in their risk assessment, a discussion of mobile phone safety.

The International Telecommunications Union (ITU) has allocated the radio band 890-915 MHz for the up-link (the signals *transmitted by* mobile phones) and the band 935-960 MHz for the down-link (the signal *received by* mobile phones) (*Skelding*). UK mobile phones use the ranges 872-960 MHz, 1710-1875 MHz and 1920-2170 MHz. GSM = 900 and 1800 bands and UMTS are expected to use 2 GHz (*Dobson et al*).

Investigating the work of radiologists X- and γ-ray imaging and therapy

Centres fortunate enough to have an X-ray machine such as the Tel-X-ometer will be able to give candidates the opportunity to produce an X-ray image themselves. In most cases, practical work in this sub-section of the unit will not be an option. A visit to the radiography and radiotherapy departments of a local hospital is an excellent way to bring the ideas of the CAT scanner and radiotherapy techniques to life.

Candidates need to understand that X- and γ -rays are hazardous in a way that other parts of the electromagnetic spectrum are not, because of their ionising properties. They need to understand that ionisation in living cells can lead to death or mutation of the cell and be able to give examples of the acute and long-term effects of such radiation and distinguish between the somatic and genetic effects.

Candidates need to understand the difference between a substance that has been irradiated and one which is radioactive.

Candidates need to know that the dose to staff can be reduced by:

- reducing the size of source used;
- increasing distance from the source (inverse-square rule);
- reducing time of exposure;
- inserting materials such as lead or concrete between the source and the person.

The dose to X-ray patients can be reduced if more sensitive X-ray emulsions or image intensifying screens are used. For radiotherapy patients, careful planning can reduce the dose to parts of the body not undergoing treatment. Candidates need to understand the balance that needs to be struck between risk and benefit to patients when exposed to radiation as part of medical diagnosis or treatment.

Candidates need to understand the terms physical and biological half-life as applied to technetium-99m tracer and complete calculations of overall half life from biological and physical half life data.

Candidates should be able to describe and explain the components the γ -camera and the principles behind their design.

Guidance on Assessment

This unit is assessed through a 1½ hour question paper with **90** marks which assesses AO1 (**45-55** %) and AO2 (**45-55** %).

Resources

Equipment

Can be obtained from: Phillip Harris Scientific & Chemical Griffin

Publications

Badawi R *Nuclear Medicine* Physics Education Vol. 36 No 6 Nov 2001

Idham M *Radiation physics and applications in Therapeutic Medicine* Physics Education Vol. 36 No 6 Nov 2001

Michael G *X-Ray Computed* Physics Education Vol. 36 No 6 Nov 2001 *Tomography*

Software

Krucible, Immersive Education www.immersiveeducation.com

Textbooks

Adams S & Allday J	*Advanced Physics*	Oxford (2000)	019 914 680 2
Ballard D *et al.*	*OCR A Level Applied Science*	Heinemann	978 0435692 12 4
Dobson K Grace D & Lovett D	*Physics*	Collins(2002)	000 713 598 X
England N Milward C & Barratt P	*Physics in Perspective*	Hodder & Stoughton (1990)	034 040 709 3
Hollins M	*Medical Physics* (Bath Advanced Science)	Nelson Thornes (2001)	017 448 253 1
Hutchings R	*Physics* (Bath Advanced Science)	Nelson Thornes (1990)	017 438 510 2
McCormick & Elliot A	*Health Physics* (Cambridge Modular Science)	CUP (2001)	052 178 726 2
Muncaster R	*Medical Physics*	Stanley Thornes (1966)	074 872 324 2
Pope J	*Medical Physics* (Heinemann Advanced Science)	Heinemann (2003)	043 557 086 2
Skelding R	*Physics Phones Home* (Supported Learning In Physics Project)	Heinemann (1998)	043 568 840 5

Video

'Medical Physics', UCL Images, 1995

Websites

Useful source of information about mobile phone technology
http://electronics.howstuffworks.com/cell-phone.htm

Networks and data communication
http://infj.ulst.ac.uk/~cbem23/b1.html

Broadband
http://www.bwww.co.uk/broadband/what-is-broadband.php

http://web.phys.ksu.edu/vqm/laserweb/Java/Prism/Prisme.htm (applet showing dispersion of, light))

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Hodder Education is the publisher partner for OCR GCE Applied Science.

Hodder Education is producing the following resources for OCR GCE Applied Science for first teaching in September 2009, which will be available in Spring 2009.

Leadbetter, C, Belanyek, A and Rouse, G. OCR Computing for A Level (2008) ISBN: 9780340967898

Leadbetter, C, Belanyek, A and Rouse, G. OCR Computing for A Level Dynamic Learning Network Edition CD ROM (2008) ISBN: 9780340968239

Approved publications

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