

The new GCSE science examinations
Findings from the monitoring of the new
GCSE science specifications:
2007 to 2008



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Contents

Executive summary	2
Introduction	3
Monitoring the new specifications	4
Schemes of assessment	6
Written papers	9
Internal assessments	16
Awarding body meetings	21
Grading standards	25
Further work	27
Appendix A: GCSE criteria for science	30
Appendix B: Schemes of assessment	31

Executive summary

In 2007 and 2008, Ofqual monitored the new specifications in GCSE science and GCSE additional science offered by the three England-based unitary awarding bodies – the Assessment and Qualifications Alliance (AQA), Edexcel, and Oxford, Cambridge and RSA Examinations (OCR). These new specifications, which were for first teaching from September 2006, were introduced following the revision of the programme of study for key stage 4 science and the *GCSE criteria for science*.

The revised criteria state that all specifications in GCSE science subjects should be unit based, whereas previous specifications comprised either linear or modular assessment. In each specification, there is the potential for candidates to resit units, though the degree to which this is possible varies significantly between the specifications. Although the *GCSE criteria for science* define the subject-specific essentials for specifications, they provide scope for a range of different assessment approaches, including the weightings of external and internal assessment.

Significant variation was evident across the different specifications in the types of assessment used and the weightings allocated to these. This variation had implications for the comparability of routes to a subject grade across awarding bodies and specifications.

Ofqual had a number of concerns regarding the validity and reliability of different assessments, and will review those from future examination series in this regard.

Ofqual recommends revision of the *GCSE criteria for science* and the development of new specifications in these subjects to ensure that different routes to a subject grade are comparable in their requirements, and that the weightings of different types of assessment are appropriate, so that candidates across the range are able to demonstrate what they know, understand and can do.

Ofqual recommends that revision of the *GCSE criteria for science* includes consideration of whether the broader aspects of 'how science works' could be more validly assessed through means different to those used currently.

AQA, Edexcel and OCR have agreed to implement a range of measures to address the concerns evident from Ofqual's monitoring of GCSE science in 2007. These measures have included amendments to the written papers and internal assessments involved. In spring 2009, Ofqual will agree with each of these awarding bodies the measures that should be implemented to address the concerns evident from its monitoring of GCSE additional science in 2008.

Introduction

Ofqual is the regulator of qualifications, examinations and tests in England. Its work ensures that children, young people and adult learners get the results their work deserves, that standards are maintained and that the qualifications learners receive count now and in the future.

The awarding bodies that offer GCSE and GCE examinations operate within a clear regulatory framework, which is set out in the following documents:

- *The statutory regulation of external qualifications in England, Wales and Northern Ireland* (2004) (QCA/04/1293, [www.ofqual.gov.uk/files/6944_regulatory_criteria_04\(1\).pdf](http://www.ofqual.gov.uk/files/6944_regulatory_criteria_04(1).pdf))
- *GCSE, GCE and AEA code of practice* (April 2008) (QCA/08/3563, www.ofqual.gov.uk/files/Code_of_practice_April_2008.pdf).

Ofqual carries out a programme of monitoring activities each year to assess the performance of awarding bodies against the requirements of each section of the code of practice. One of these activities is the scrutiny programme – an in-depth study of the examination process across a range of specifications offered by the different awarding bodies each year. Each scrutiny involves a team of subject expert consultants, who observe awarding body meetings, analyse question papers, mark schemes and internal assessments, and review a sample of candidates' work. Each scrutiny results in a report on how the awarding body should improve its provision.

The scrutiny of a qualification aims to:

- determine whether the required qualification criteria and associated codes of practice have been met
- determine whether the assessments were fair and effective in measuring achievement by candidates in respect of the stated assessment objectives
- determine whether the procedures designed to ensure consistency of practice and comparability of standards were implemented effectively
- identify any aspects of the specification that appear to have constrained fair and effective examinations
- identify any good practice worthy of encouragement and dissemination, to promote continuing improvement in the quality of examinations.

Monitoring the new specifications

In 2007 and 2008, Ofqual carried out scrutinies of the new specifications in GCSE science and GCSE additional science offered by the three England-based unitary awarding bodies – the Assessment and Qualifications Alliance (AQA), Edexcel, and Oxford, Cambridge and RSA Examinations (OCR).¹

The 2007 scrutinies addressed the five GCSE science specifications offered by these awarding bodies, while the 2008 scrutinies addressed their four GCSE additional science specifications.² GCSE additional science is a new qualification, equivalent to one GCSE, which builds on the 'core' work covered in GCSE science (also a single GCSE). The *GCSE criteria for science* indicate that taken together, these two qualifications 'should be equivalent to the GCSE double award: science' that was available previously.

The new specifications, which were for first teaching from September 2006, were introduced following the revision of the programme of study for key stage 4 science and the *GCSE criteria for science*. The revised criteria are provided in Appendix A. They require that all specifications in GCSE science subjects give students opportunities to:

- develop their interest in, and enthusiasm for, science
- develop a critical approach to scientific evidence and methods
- acquire and apply skills, knowledge and understanding of 'how science works' and its essential role in society
- acquire scientific skills, knowledge and understanding necessary for progression to further learning.

The criteria also indicate the four areas that the skills, knowledge and understanding of 'how science works' should comprise, with either three or four different strands provided for each of these. The four areas are:

- data, evidence, theories and explanations

¹ In the same period, the Department for Children, Education, Lifelong Learning and Skills (DCELLS) carried out scrutinies of the GCSE science and GCSE additional science specifications offered by the Welsh Joint Education Committee (WJEC).

² For the 2007 scrutinies, Ofqual has agreed action plans with AQA, Edexcel and OCR. For the 2008 scrutinies, these action plans will be agreed in spring 2009.

- practical and enquiry skills
- communication skills
- applications and implications of science.

For each of GCSE science and GCSE additional science the criteria specify a range of subject content. In each case, the four areas of skills, knowledge and understanding detailed above are required to be set in the context of this content.

The criteria indicate that all candidates for GCSE science subjects are required to demonstrate the three assessment objectives in the context of the prescribed skills, knowledge and understanding.

Schemes of assessment

The *GCSE criteria for science* state that all specifications in GCSE science subjects should be unit based, whereas previous specifications comprised either linear or modular assessment.³ In each specification, there is the potential for candidates to resit these units, though the degree to which this is possible varies significantly between the specifications.

Although the *GCSE criteria for science* define the subject-specific essentials for specifications, they provide scope for a range of different assessment approaches. This is in part because specifications are required to include a minimum weighting of 25 per cent for each of external and internal assessment. As a result of this, the proportion of marks that these forms of assessment each contribute to the qualification overall can vary significantly between the specifications.

For GCSE science, the three unitary awarding bodies offer five specifications – there are two from AQA (A and B), one from Edexcel and two from OCR (A and B).

The number of externally assessed question papers that each specification comprises varies from as few as two to as many as six. There is a corresponding variation across the specifications in the durations of the individual papers and in their individual weightings in the assessment as a whole. Across the specifications, the combined duration of the papers varies from two to three hours, while their combined weighting ranges from 60 to 75 per cent of the assessment. The specifications also vary in terms of the subject content addressed by individual papers. In some cases they address one of biology, chemistry or physics, while in other cases they address all of these. A range of different types of question paper is used – objective test papers (or papers made up of objective style questions), structured papers made up of short answer questions, and papers that use a combination of these question types.⁴ Most of the specifications require candidates to take only one of these types of paper.

Each of the specifications includes compulsory internal assessment, the weighting of which ranges across the specifications from 25 to 40 per cent of the assessment as a whole. The approaches to internal assessment adopted in the AQA and Edexcel

³ With unitised qualifications, the individual assessments can be taken by candidates at different times, whereas with linear and modular qualifications, all or the majority of the assessment takes place at the end of the course.

⁴ Objective test and similar papers require candidates to select responses from a series provided, or in some cases to manipulate information provided in other ways. Structured papers require candidates to generate responses independently.

specifications meet most of the requirements for the controlled assessment now used in new GCSE specifications,⁵ though they pre-date the revision of the GCSE qualification criteria that led to these. A significant difference between the AQA and Edexcel specifications, however, is that candidates submit one assessment in biology, chemistry or physics for AQA, compared to one assessment in each of these for Edexcel. By comparison, the internal assessments in the OCR specifications, though different from those offered previously, are of a more traditional coursework model.

For GCSE additional science, the three unitary awarding bodies offer four specifications – there are one each from AQA and Edexcel, and two from OCR (A and B).

In terms of their overall structure, each of the OCR specifications is similar to the corresponding specification for GCSE science, while the AQA specification is also similar to one of those offered for GCSE science. However, the Edexcel specification provides a large number of assessment routes compared to that for GCSE science, requiring candidates to select two assessment types from a choice of three for each unit. Consequently, the relative weightings for external and internal assessment in this specification can vary significantly (from 60 to 30 per cent and from 70 to 40 per cent). The large number of assessment routes available in this case is in contrast to the limited number of routes available in the specifications from the other awarding bodies.

Across the specifications, there is similar variation regarding the externally assessed question papers to that described for GCSE science. Again, the number of papers may range from two to six, and there is a corresponding variation in their individual durations and weightings. Equally, the papers may address one or all of biology, chemistry and physics, and they may be objective test papers (or papers made up of objective style questions), structured papers made up of short answer questions, or papers that use a combination of these question types. However, the combined duration of the papers in this case can vary significantly between the specifications – from one hour to two hours and 45 minutes. Similarly, their combined weighting can range from 30 to 75 per cent of the assessment. These two forms of variation largely result from the optional routes in the Edexcel specification, which enable candidates to take either objective test papers or structured papers, or both, for each unit.

⁵ Controlled assessments are completed by candidates under supervised conditions. They are either set by the awarding body and marked by the centre, or set by the centre and marked by the awarding body.

As in the case of GCSE science, each of these specifications includes compulsory internal assessment. The weighting of this again ranges across the specifications from 25 to 40 per cent of the assessment as a whole, and the assessments are broadly similar in their requirements to those for GCSE science. However, the Edexcel specification also includes an optional internal assessment for each unit, which is of a more traditional model than the compulsory assessment.

Summaries of the different schemes of assessment for GCSE science and GCSE additional science are provided in Appendix B.

Ofqual is concerned that where different specifications involve significantly different forms of assessment (such as differences in question/task type or in the weightings of external and internal assessment), it is difficult to ensure the comparability of routes to a subject grade across the awarding bodies. (For example, candidates across different assessment routes may have demonstrated significantly different combinations of the assessment objectives.)

Equally, where different routes within an individual specification involve significantly different forms of assessment, it is difficult to ensure the comparability of routes to a subject grade across the candidates in question.

An additional concern is that where specifications comprise a large number of discrete assessments with low weightings, it can be difficult for these individual assessments each to contain sufficient scope to discriminate accurately across the full range of candidates' performance.

Actions

Ofqual recommends revision of the *GCSE criteria for science* and the development of new specifications in these subjects to ensure that different routes to a subject grade, both across and within specifications, are comparable in their requirements.

Ofqual requires future specification development to ensure that individual assessments have sufficient scope to discriminate accurately across the full range of candidates' performance.

Written papers

The written papers for GCSE science and GCSE additional science vary significantly across the different specifications in the question types that they employ, and in some cases there is also similar variation within specifications.⁶

Objective test and objective style question papers

The external assessment for each of AQA GCSE science A and Edexcel GCSE science consists of a series of objective test question papers. These are also available as an optional route for each of biology, chemistry and physics for Edexcel GCSE additional science. Similarly, a significant proportion (75 per cent) of the external assessment for each of OCR GCSE science A and OCR GCSE additional science A consists of papers comprising objective style questions.⁷

For AQA GCSE science A, there are six equally-weighted objective tests, which together represent 75 per cent of the assessment for the specification as a whole. The units Biology 1, Chemistry 1 and Physics 1 are all divided into two sections (1a and 1b), each of which is assessed through a 30-minute test. Each test is available at foundation and higher tier in the November, March and June examination series. Candidates may choose which tier to take on the day of the examination. The tests use two types of question – matching (where candidates are required to match options A to D with options 1 to 4) and multiple choice (where candidates select one response from a range 1 to 4).

For Edexcel GCSE science, there are six equally-weighted objective tests, which together represent 60 per cent of the assessment for the specification as a whole. Again, the units Biology 1, Chemistry 1 and Physics 1 are each divided into two sections (1a and 1b) each of which is assessed through a test, though in this case the duration of each test is 20 minutes. As with AQA, each test is available at foundation and higher tier in the November, March and June examination series, with candidates again able to choose which tier to take on the day of the examination. The tests use multiple choice questions (where candidates select one response from a range A to D).

For Edexcel GCSE additional science, there are three optional objective tests – one for each of the units Biology 2, Chemistry 2 and Physics 2. As with GCSE science, the tests are equally weighted, but since they are optional they may together

⁶ The descriptions that follow in this section relate to the provision in 2007 and 2008.

⁷ Objective style questions are broadly similar to those in standard objective test papers in their requirements, but involve a more varied range of question types.

represent 0, 10, 20 or 30 per cent of the assessment for the specification as a whole, depending on the number of tests taken. The tests are like those for GCSE science in terms of their duration, availability and question type.

For each of OCR GCSE science A and OCR GCSE additional science A, there are three equally-weighted papers comprising objective style questions. In each case, these papers together represent 50 per cent of the assessment for the specification as a whole. Each paper assesses one module in each of biology, chemistry and physics, and has a duration of 40 minutes. Each paper is available at foundation and higher tier in the January and June examination series. In contrast to the AQA and Edexcel papers, candidates must enter in advance for one of these tiers. The papers use a range of objective style question types – for example selecting one or more correct options from a list provided, putting options provided into a correct order, adding words provided to gaps in sentences, matching sets of statements provided, and indicating if statements are true or false.

The question papers for these specifications vary in numerous ways, such as the subject content they address, the number of different question types they employ, and the number and duration of the papers that candidates are required to complete. However, several common issues were evident across the papers.

In each case, Ofqual was concerned that the question types used provided insufficient opportunity for more able candidates, particularly those at higher tier, to demonstrate the extent of their scientific knowledge, understanding and skills. The question types restricted the range of types of responses that candidates could provide. There was little or no scope for them to demonstrate various aspects of the assessment objectives and grade descriptions – for example ‘develop arguments’ (from assessment objective 2a) and, given the lack of requirement for extended writing, ‘use technical vocabulary and techniques with fluency’ (from the grade A description). In each case, candidates would only be able to demonstrate such skills in the other assessments comprising the qualification. This was a particular concern in the case of AQA GCSE science A and Edexcel GCSE science since objective test papers account for 75 per cent and 60 per cent, respectively, of the overall weightings of these specifications.

The question types used also restricted the depth of specification coverage that was possible in these papers. Where questions were worth a low number of marks and/or were largely self-contained (rather than linking into ensuing questions), it was possible for them to address a wide range of specification content, but this tended to be fairly superficial. This issue was noted particularly for Edexcel GCSE science, OCR GCSE science A and OCR GCSE additional science A.

Although candidates demonstrated a range of levels of performance on the papers for each specification, Ofqual was concerned that this may to some extent have been

the result of factors other than the demand of the scientific knowledge, understanding and skills being assessed. The amount and complexity of the information that candidates were required to process in order to respond to a question was one such factor. In the case of AQA GCSE science A, the information in some instances was judged as being insufficiently accessible for candidates at foundation tier, owing to both its level and its extent. Similarly, for Edexcel GCSE science, there were instances where some of the wording used in questions lacked clarity or was potentially ambiguous. Another factor that may have affected the difficulty of these papers was the amount of time available for candidates to complete them. For the AQA GCSE science A papers, there were 36 marks available in a duration of 30 minutes, which was considered to be a challenging requirement, given the questions involved. This was also the case, though to a lesser extent, for the Edexcel GCSE science papers, where there were 24 marks available in a duration of 20 minutes.

With objective tests and similar assessments, a significant element of their demand results from the plausibility of the 'distractors' that are used. (These are the incorrect responses to a question, the plausibility of which should be increased in line with the anticipated demand of the question.) Some instances were noted, for example in the case of Edexcel GCSE science and OCR GCSE additional science A, of distractors that Ofqual judged to be too obviously incorrect for students at this level.

Many of the questions across these papers made use of scientific contexts – these have the potential to enable candidates to engage with the broader aspects of 'how science works'. However, Ofqual noted instances in each case of questions where the science being assessed did not depend on candidates engaging with the context addressed, so that this context was in fact unnecessary. For Edexcel GCSE science, a small number of instances were also noted of questions relating to scientific contexts that did not assess scientific content appropriately.

The tiered question papers in GCSE science subjects are each required to target five grades – A*, A, B, C and D for higher tier, and C, D, E, F and G for foundation tier. For the objective test papers for Edexcel GCSE science and Edexcel GCSE additional science, Ofqual had a concern that their low mark allocations (24 marks in each case) would make it difficult for them to separate candidates into these grades in a reliable fashion.

Actions

AQA, Edexcel and OCR have each agreed to implement a range of measures to ensure that the findings from the monitoring of the GCSE science papers in 2007 will inform the setting of future question papers and mark schemes. Each awarding body will also continue to use the relevant statistical data available about question paper performance to refine the targeting of questions at levels of demand in future examination series.

Ofqual will agree with AQA, Edexcel and OCR the measures that should be implemented to address the concerns noted from the monitoring of the GCSE additional science papers in 2008.

Ofqual will review future question papers and mark schemes for these units to ensure that they are valid and reliable. This will include consideration of:

- the opportunities provided for more able candidates to show what they know, understand and can do⁸
- any factors other than demand that may have affected the difficulty of papers
- the demand of questions in terms of the plausibility of incorrect responses
- the appropriateness of those questions assessing the broader aspects of 'how science works'.

Ofqual recommends revision of the *GCSE criteria for science* and the development of new specifications in these subjects to ensure that the weightings of different types of assessment are appropriate, so that candidates across the range are able to demonstrate what they know, understand and can do.

Ofqual recommends that revision of the *GCSE criteria for science* includes consideration of whether the broader aspects of 'how science works' could be more validly assessed through means different to those used currently.

Ofqual requires future specification development to ensure that the mark allocations for individual assessment units are appropriate, so that candidates can be credited reliably for what they know, understand and can do.

Structured question papers

The external assessment for each of AQA GCSE science B, AQA GCSE additional science, OCR GCSE science B and OCR GCSE additional science B consists of a series of structured question papers. These papers also form a proportion (25 per cent) of the external assessment for each of OCR GCSE science A and OCR GCSE additional science A. In addition, structured papers are available as an optional route for each of biology, chemistry and physics for Edexcel GCSE additional science.

⁸ In this regard, OCR has submitted for consideration by the Qualifications and Curriculum Authority (QCA) a revised assessment model for the objective style question papers. In this revised model, approximately 30 per cent of the questions will require candidates to generate responses independently.

For each of AQA GCSE science B and AQA GCSE additional science, there are three equally-weighted structured papers. In each case, these papers together represent 75 per cent of the assessment for the specification as a whole. The units Biology 1, Chemistry 1 and Physics 1 for GCSE science B, and Biology 2, Chemistry 2 and Physics 2 for GCSE additional science, are each assessed through a 45-minute paper. Each paper is available at foundation and higher tier in the January and June examination series. The papers generally use short answer questions. Some multiple choice questions are also used, particularly at foundation tier, though this varies across the units.

For each of OCR GCSE science B and OCR GCSE additional science B, there are two equally-weighted structured papers. In each case, these papers together represent 67 per cent of the assessment for the specification as a whole. Each paper assesses one module in each of biology, chemistry and physics, and has a duration of 60 minutes. Each paper is available at foundation and higher tier in the January and June examination series. The papers generally use short answer questions, but also include some objective style questions.

For each of OCR GCSE science A and OCR GCSE additional science A, there is one structured paper. In each case, this paper has the same weighting in the assessment for the specification as a whole as each of the objective style papers (17 per cent). Each paper assesses 'ideas in context', uses pre-release material and has a duration of 45 minutes. The paper for GCSE science assesses 'ideas about science' in a range of contexts, whereas that for GCSE additional science assesses content in each of biology, chemistry and physics. Each paper is available at foundation and higher tier in the June examination series only. The papers generally use short answer questions relating to the pre-release material. There are also a small number of objective style questions related to this, particularly at foundation tier.

For Edexcel GCSE additional science, there are three optional structured papers – one for each of the units Biology 2, Chemistry 2 and Physics 2. The papers are equally weighted, but since they are optional they may together represent 0, 10, 20 or 30 per cent of the assessment for the specification as a whole, depending on the number of papers taken. Each paper has a duration of 30 minutes. The papers are available at foundation and higher tier in the November, March and June examination series. The papers generally use short answer questions. Some multiple choice questions are also used at foundation tier, though this varies across the units.

Variation was evident, both across the different specifications and across different units of individual specifications, in the extent to which these question papers provided opportunities for more able candidates to demonstrate the extent of their scientific knowledge, understanding and skills. In some cases, question papers provided scope for candidates to show higher-order skills (such as developing strategies and extended writing) or were demanding in their scientific content. This

was noted particularly for AQA GCSE science B, AQA GCSE additional science and OCR GCSE additional science A. However, there were also instances across the different specifications of question papers that provided little opportunity for candidates to demonstrate higher-order skills. This was owing to the papers including a significant proportion of objective type questions and/or to them using short answer questions that were fairly limited in their requirements or in the scientific content that they addressed. For Edexcel GCSE additional science, there was a concern that the low mark allocation for the structured papers (30 marks in each case) restricted their potential to include demanding questions.

Similar variation was evident across the specifications in the extent to which question papers assessed the broader aspects of 'how science works'. In some cases, such as for AQA GCSE additional science, instances were noted of questions that were set appropriately in relevant, real-life contexts. However, in other cases, the assessment of the broader aspects of 'how science works' was more limited, with instances noted of questions where the science being assessed did not depend upon candidates engaging with the context provided. This issue was noted particularly for OCR GCSE additional science A – the use of pre-release source material in this paper provided considerable scope for it to assess the broader, contextual aspects of 'how science works', but many of the questions did not in fact require candidates to engage with the material and could have been set on a more standard written paper.

Actions

AQA and OCR have each agreed to implement a range of measures to ensure that the findings from the monitoring of the GCSE science papers in 2007 will inform the setting of future question papers and mark schemes. (There are no structured papers for Edexcel GCSE science.) Each awarding body will also continue to use the relevant statistical data available about question paper performance to refine the targeting of questions at levels of demand in future examination series.

Ofqual will agree with AQA, Edexcel and OCR the measures that should be implemented to address the concerns noted from the monitoring of the GCSE additional science papers in 2008.

Ofqual will review future question papers and mark schemes for these units to ensure that they are valid and reliable. This will include consideration of:

- the opportunities provided for more able candidates to show what they know, understand and can do
- the appropriateness of those questions assessing the broader aspects of 'how science works'.

Ofqual recommends that revision of the *GCSE criteria for science* includes consideration of whether the broader aspects of 'how science works' could be more validly assessed through means different to those used currently.

Ofqual requires future specification development to ensure that the mark allocations for individual assessment units are appropriate, so that candidates across the range are able to demonstrate what they know, understand and can do.

Internal assessments

As with the written papers discussed above, the internal assessments for GCSE science and GCSE additional science vary significantly across the different specifications in the approach they adopt, and there is also some similar variation within specifications.⁹

AQA

The internal assessment for each of the AQA specifications in GCSE science and GCSE additional science is the centre-assessed unit (CAU). In each case, this assessment represents 25 per cent of the assessment for the specification as a whole. This unit is in two parts – the investigative skills assignment (ISA) worth 34 marks, and the practical skills assessment (PSA) worth six marks.

The ISAs are 45-minute, non-tiered written tests, taken under controlled conditions. Each ISA is set by AQA, marked by the teacher/centre using marking guidance provided by AQA, and moderated by AQA. Candidates may take ISAs when judged ready by their teacher. At any given point, there are six ISAs available for GCSE science and six available for GCSE additional science – two in each of biology, chemistry and physics in each case.¹⁰ Candidates may attempt any number of the ISAs available, but for each candidate, centres are required to submit only their highest mark, whether for biology, chemistry or physics.

The ISAs considered as part of these scrutinies were the initial model, which addressed the practical work that a candidate had carried out on an approved topic. Each ISA was in two parts. Section 1 comprised questions specifically about the practical work that the candidate had carried out, while section 2 comprised questions relating to a previously unseen set of data. (Candidates were expected to apply the knowledge and skills they had developed from their practical work to the data.)

The PSA is a holistic assessment of a candidate's implementation of their practical work. It is completed by the teacher/centre using marking guidance provided by AQA, but is not moderated subsequently by AQA.

Overall, the ISAs were appropriately demanding, providing suitable opportunity for the full range of candidates to demonstrate their scientific knowledge, understanding

⁹ The descriptions that follow in this section relate to the provision in 2007 and 2008.

¹⁰ The first year of teaching for GCSE science was an exception to this, there being nine ISAs available – three in each of biology, chemistry and physics.

and skills. However, some variation was evident in the demand and complexity of the ISAs in each case.

The ISAs were able to assess many of the broader aspects of 'how science works' in a relevant, meaningful way since they were set in relevant contexts, based on the practical work carried out by candidates, and gave scope for candidates to work with the data obtained from this.

However, Ofqual had concerns regarding section 2 of the ISAs. The questions in this section did not require candidates to make any reference to the data they had obtained through their practical work, focusing more on knowledge that candidates had developed through this work. This reduced their appropriateness as a form of internal assessment, since they were assessed by teachers who, although trained, had not been standardised formally, as well as their scope to assess the broader aspects of 'how science works'. Also, since each ISA was available for a two-year period, information about the content of this section could be passed between candidates, thereby creating a risk to security.

Actions

In response to Ofqual's concerns, AQA has revised section 2 of the investigative skills assignments (ISAs) so that a significant proportion of the questions relate to candidates' own practical work. Centres will be informed of the revision, which will be effective from September 2009.

Edexcel

The compulsory internal assessment for each of Edexcel GCSE science and Edexcel GCSE additional science comprises the internal assessment activities (IAAs) and the assessment of practical skills. In each case, these assessments account respectively for 30 per cent and 10 per cent of the assessment for the specification as a whole. An optional internal assessment is also available for each unit for GCSE additional science – the centre devised activities (CDAs), which may represent 0, 10, 20 or 30 per cent of the assessment for the specification as a whole, depending on the number of activities undertaken.

The IAAs are 45-minute, non-tiered written tests, taken under controlled conditions. Each IAA is set by Edexcel, marked by the teacher/centre using marking guidance provided by Edexcel, and moderated by Edexcel. Candidates may take IAAs when judged ready by their teacher. At any given time, there are 24 IAAs available for GCSE science and 12 IAAs available for GCSE additional science – either two IAAs or one IAA, respectively, for each of the four topics in biology, chemistry and physics. Candidates may attempt any number of the IAAs available, but for each candidate, centres are required to submit only their highest mark for each of biology, chemistry and physics.

The IAAs considered as part of these scrutinies were the initial model, each comprising a series of short answer questions relating to one of the specification topics.

The assessment of practical skills is a holistic assessment of a candidate's implementation of their practical work. It is completed by the teacher/centre using marking guidance provided by Edexcel, but is not moderated subsequently by Edexcel.

The optional CDAs for GCSE additional science may be completed by candidates for any or all of the units Biology 2, Chemistry 2 and Physics 2. They are both set and marked by the teacher/centre using guidance provided by Edexcel, and are moderated by Edexcel. Each is worth 24 marks, with candidates assessed for written communication, analysis and the applications and implications of science.

Although the IAAs might address subject matter that had been covered in candidates' practical work, they were knowledge-based tests that were not linked directly to this work. This was not appropriate as a form of internal assessment since they were assessed by teachers who had not been standardised. Also, since the IAAs were each available for a two-year period, information about their subject content could be passed between candidates, thereby creating a risk to security.

There was considerable variation across the IAAs in the amount of specification content and the range of assessment objectives that they addressed, which meant that they were not comparably demanding. In addition, the IAAs did not provide suitable opportunity for the full range of candidates to demonstrate their scientific knowledge, understanding and skills. The specification content assessed was demanding in some cases, which restricted their accessibility to less able candidates, while the question types used did not enable more able candidates to show higher-order skills. The lack of emphasis on extended writing in the IAAs was a particular concern given that the external assessment of this specification consists entirely of objective test question papers.

Ofqual also had several concerns regarding the CDAs. The guidance to centres about setting tasks for these was limited, which meant that there was potential for tasks to vary in their demand across different centres. Also, the marking criteria were both unclear and inappropriately demanding, which meant that they might not be applied consistently by centres and that candidates' marks might not reflect the extent of their scientific knowledge, understanding and skills.

Actions

In response to Ofqual's concerns, Edexcel has revised the internal assessment activities (IAAs) so that they are linked directly to candidates' practical work and are assessed through generic marking criteria, and has also reduced the number of them

available for each of GCSE science and GCSE additional science to six. Centres have been informed of the revision, which was effective from September 2008.

Ofqual will monitor the implementation of the revised IAAs by Edexcel. Ofqual will also agree with Edexcel the measures that should be implemented to address the concerns noted from the monitoring of the centre devised assessments (CDAs).

OCR

The internal assessment for each of the OCR specifications in GCSE science and GCSE additional science is a 'skills assessment'. In each case, this assessment represents 33 per cent of the assessment for the specification as a whole, and is marked by the teacher/centre using marking guidance provided by OCR, and then moderated by OCR.

For GCSE science A, the internal assessment comprises practical data analysis (of primary data) and a case study (on a topical scientific issue). The practical data analysis is worth 16 marks, with candidates assessed for interpretation and evaluation. The case study is worth 24 marks, with candidates assessed for selection and use of information, understanding of case, conclusion and presentation.

For GCSE additional science A, the internal assessment comprises a practical investigation (with scope for a wide range of activities and approaches). This is worth 40 marks, with candidates assessed for strategy, collecting data, interpreting data, evaluation and presentation.

For GCSE science B, the internal assessment comprises a set of 'can-do tasks' and a report on science in the news. The can-do tasks are provided by OCR and are available at three levels – basic, intermediate and advanced. Candidates may do up to eight of the tasks, which are worth a maximum of 24 marks. The tasks assess candidates' practical capabilities and explore the ways in which scientific evidence is collected. The report on science in the news is completed under supervision and is worth 36 marks. It is based on research that the candidate has completed about how scientific data and ideas are dealt with by the media. This research uses OCR stimulus material as well as information from other sources.

For GCSE additional science B, the internal assessment comprises a research study, data task and practical skills. The research study is completed under supervision and is worth 24 marks. It is based on research that the candidate has completed about various aspects of scientific ideas. This research uses OCR stimulus material as well as information from other sources. The data task is worth 30 marks, and requires candidates to analyse and evaluate data, as well as to plan relevant further work (though this will not be carried out). The practical skills are assessed holistically out of six marks.

The internal assessment for each of these specifications provided appropriate opportunity for the full range of candidates to demonstrate their scientific knowledge, understanding and skills. In each case, there was the potential for centres and candidates to undertake a wide range of tasks or to adopt a wide range of approaches. In most cases, clear and appropriate guidance was provided to centres about setting tasks, ensuring the authenticity of candidates' work and assessing candidates' work.

However, for OCR GCSE science B, Ofqual was concerned that some elements of the initial marking criteria for the report on science in the news were not sufficiently clear to be applied consistently by centres and moderators.

Actions

In response to Ofqual's concerns, OCR has revised the marking criteria for the OCR GCSE science B report on science in the news to ensure that they are appropriate. Centres have been informed of this revision, which was effective from September 2008.

Awarding body meetings

Through its scrutinies in 2007 and 2008 of GCSE science and GCSE additional science, Ofqual observed a large number of awarding body meetings related to these new specifications. Seven meetings related to setting question papers, 18 related to standardising examiners and markers, 15 related to standardising moderators, and 26 related to awarding grades. Generally, these meetings were conducted in line with the detailed requirements of the *GCSE, GCE and AEA code of practice*.

Setting question papers

The GCSE science and GCSE additional science question papers for AQA and Edexcel were each set by a senior examiner, while for OCR, where these question papers have multiple sections, the different sections were set by different senior examiners. In each case, a question paper evaluation committee (QPEC) comprising a team of senior examiners then met to ensure that the question papers (and related mark schemes) met the requirements of the assessment criteria from the specification and were of consistently high quality.

The QPEC meetings that Ofqual observed were generally well conducted, involving detailed consideration of materials that had been prepared appropriately. The majority of the amendments made in each case were to ensure that question papers were sufficiently clear and accessible to candidates, with good use of comments from language specialists made at the Edexcel meetings. However, for AQA and Edexcel, it was not always clear how the coverage in the question papers of the specification content would be monitored over time. In addition, for Edexcel and OCR, where there were optional routes either within or across specifications, the comparability of these routes was not always considered.

Standardising examiners and markers

The written papers for each of the AQA, Edexcel and OCR specifications in GCSE science and GCSE additional science were marked online using the awarding bodies' established electronic processes. Details regarding the development of these processes are available on the Ofqual website (www.ofqual.gov.uk/110.aspx). The marking was undertaken by a range of different types of examiner and/or marker in each case, based on the extent to which candidates' responses would be technically complicated, or relatively straightforward, to mark.

The examiners and markers for each specification were standardised to ensure that they had a well-founded and common understanding of the requirements of the mark

schemes and were able to apply them reliably to candidates' work.¹¹ This process took place at face-to-face meetings for the AQA specifications, while for the Edexcel and OCR specifications it was conducted online.

In each case, the standardisation of examiners and markers was preceded by a meeting of the senior examiners for the paper. Based on their preliminary marking of a sample of candidates' work, the senior examiners finalised the mark scheme. In addition, they selected and agreed the marks for a range of candidates' work for use in standardising examiners and markers, and in monitoring their marking subsequently. The examiners and markers for each specification were trained using these examples of candidates' work (whether at face-to-face meetings or online), and were also required to mark a number of them to an agreed standard in order to qualify for 'live' marking. Their marking was then monitored on an ongoing basis, through further examples of candidates' work appearing at regular intervals in their allocation.

The meetings that Ofqual observed relating to the standardisation of examiners and markers were generally well conducted, involving appropriate discussion of mark schemes and consideration of a suitably illustrative range of candidates' work. However, there was a concern for OCR that where meetings were not attended in full by all of the senior examiners involved in setting papers and monitoring examiners and markers, the development of an understanding of the mark scheme that was both well-founded and common could be restricted.

Standardising moderators

The internal assessments for each of the AQA, Edexcel and OCR specifications in GCSE science and GCSE additional science were marked by internal assessors in centres, with a sample of candidates' work then moderated by the awarding body in each case to ensure that this was in line with agreed standards.¹²

Each awarding body had arrangements in place to ensure that candidates' work was marked consistently and appropriately. These included:

- procedures for setting, authenticating/supervising and assessing candidates' work

¹¹ The standard objective test papers for AQA GCSE science A, Edexcel GCSE science and Edexcel GCSE additional science were exceptions to this. These papers were computer-marked and therefore there were no examiners or markers to standardise for them.

¹² The assessment of candidates' practical skills for AQA and Edexcel was an exception to this, being conducted by the centre but not moderated subsequently by the awarding body.

- providing instructions and guidance to centres and internal assessors
- training and standardising moderators
- monitoring the work of moderators to ensure that agreed standards were being applied.

However, some variation was evident in the meetings that Ofqual observed relating to the standardisation of moderators, which to some extent was because of the differences in the types of assessment involved.

The meetings for the AQA investigative skills assignments (ISAs) and for the OCR skills assessments were well conducted and the attendees in each case had been required to complete appropriate preliminary work. Although the range of candidates' work considered at the meetings was relatively limited in some cases, the largely generic nature of the assessments in each case meant that moderators should generally have been able to acquire a common understanding of the agreed standards. There was an appropriate emphasis at these meetings on providing clear and consistent guidance to centres and internal assessors.

The meetings for the Edexcel internal assessment activities (IAAs) and centre devised activities (CDAs) were well conducted in some respects, though several concerns were also evident regarding these. For the IAAs, a range of candidates' work was considered at each of the meetings observed. However, owing to the large number of different IAAs available, and the very specific nature of each, it was difficult for the consideration of candidates' work to ensure that moderators had a common understanding of the agreed standards in all IAAs. It was also noted that the moderation of the IAAs in 2007 involved the use of marking guidelines that were different to those used by centres, which had themselves used two different versions of these. Consequently, it was difficult for the awarding body to ensure that candidates' work had been marked to common and appropriate standards (and this was particularly the case where the candidates' work had not been moderated subsequently). For the CDAs, although the senior moderator had produced supporting guidance for use in the moderation process, centres had access to only the marking criteria, which had not discriminated effectively. Consequently, some of the marks in the examples of candidates' work considered did not reflect the scientific knowledge, understanding and skills demonstrated, and it was not clear that moderators had a common understanding of the agreed standards.

Awarding grades

When candidates' work has been marked, an awarding committee meets to set grade boundaries for each unit and to determine the grade outcomes for the specification as a whole. The awarding committee comprises the chair of examiners, chief examiner, the principal examiner and principal moderator for each unit, and at least

one awarding body officer. Awarders review candidates' work and a range of statistical information as set out in section 6 of the *GCSE, GCE and AEA code of practice* to determine the A/B, C/D and D/E boundaries at higher tier, and the C/D and F/G boundaries at foundation tier. The remaining boundaries are calculated mathematically from those set judgementally.

In the case of objective test units (AQA GCSE science A and Edexcel GCSE science and additional science), there is no candidates' work for the awarding committee to review, owing to the nature of the assessment. Instead, the committee consider statistical evidence and item level data – that is, information on how well the questions have discriminated between candidates.

At the awarding meetings, awarding committees review an appropriate amount of candidates' work with a range of statistical information, and use their collective professional judgement to recommend grade boundaries for each unit.

In most cases, meetings were well run and followed the procedures set out in the code of practice. However, the code requires the awarding committee to consider the outcomes for the specification as a whole, once the unit boundaries have been set. At the Edexcel awarding meetings for GCSE science in 2007 and for GCSE science and GCSE additional science in 2008, the awarding body was unable to present the overall qualification outcomes to the committee at the end of the awarding meeting. This was partly owing to technical difficulties and partly owing to the complexity of the specifications.

Grading standards

The *GCSE, GCE and AEA code of practice* requires awarding bodies to use a range of qualitative and quantitative evidence in setting grade boundaries for individual units. It requires that grade boundaries 'reflect the quality of candidates' work, informed by the relevant technical and statistical evidence'.

Following the June 2007 and June 2008 examination series, Ofqual reviewed a sample of candidates' work from each awarding body. Generally, the judgement was that these samples were in line with expectations for the internal assessments, but not for the written papers.

In some cases, the limitations evident in candidates' work were the result of there being insufficient opportunity in the assessments for the candidates to demonstrate what they knew, understood and could do. In other cases, candidates' performance on the assessments had been limited, and grade boundaries were therefore set at a low proportion of the marks available.

The instances where candidates had difficulty in accessing assessments may have been caused by centres being unfamiliar with the requirements of the new specifications. Equally, since these new specifications are unitised, candidates may resit assessments, and may also take them at various points through the course (rather than all or the majority of the assessments taking place at the end of the course, which was the case for the previous linear and modular specifications). These factors may have affected the degree to which candidates were suitably prepared for these assessments; on a similar note, the GCSE science candidates in 2007 were from year 10 rather than year 11.

AQA, Edexcel and OCR are each working to manage the various technical difficulties involved in ensuring that appropriate standards are set in these new specifications. In summer 2008, these awarding bodies alerted Ofqual to some disparities in grading standards both between the awarding bodies and in comparison to those from previous specifications. In order to ensure that learners could be assured that the standards applied to them had been carefully checked and that their grades truly reflected their attainment, Ofqual asked AQA to bring its grading standards in line with those of Edexcel and OCR.

Actions

Ofqual requires the awarding bodies to ensure that future assessments provide appropriate opportunities for the full range of candidates to show what they know, understand and can do.

Ofqual requires the awarding bodies to set grade boundaries so that:

- they can be confident that these are in line with national standards
- standards are maintained as specifications become established.

Ofqual will agree with the awarding bodies the measures necessary to ensure that grade boundaries are set appropriately.

Further work

Below is a summary of the actions already taken or to be taken in future by the awarding bodies and Ofqual in response to the findings of this report.

Current specifications

In response to Ofqual's concerns from the monitoring of GCSE science in 2007, AQA, Edexcel and OCR have each made some changes to the assessments involved.

AQA has revised section 2 of the investigative skills assignments (ISAs) so that a significant proportion of the questions relate to candidates' own practical work. Centres will be informed of the revision, which will be effective from September 2009.

Edexcel has revised the internal assessment activities (IAAs) so that they are linked directly to candidates' practical work and are assessed through generic marking criteria, and has also reduced the number of them available for each of GCSE science and GCSE additional science to six. Centres have been informed of the revision, which was effective from September 2008. Ofqual will monitor the implementation of the revised IAAs by Edexcel.

OCR has revised the marking criteria for the OCR GCSE science B report on science in the news to ensure that they are appropriate. Centres have been informed of this revision, which was effective from September 2008.

OCR has submitted for consideration by the Qualifications and Curriculum Authority (QCA) a revised assessment model for the objective style question papers. In this revised model, approximately 30 per cent of the questions will require candidates to generate responses independently.

Each awarding body has agreed to implement a range of measures to ensure that the findings from the monitoring of the GCSE science written papers in 2007 will inform the setting of future question papers and mark schemes. Each awarding body will also continue to use the relevant statistical data available about question paper performance to refine the targeting of questions at levels of demand in future examination series.

Ofqual will agree with AQA, Edexcel and OCR the measures that should be implemented to address the concerns noted from the monitoring of the GCSE additional science written papers in 2008. Ofqual will also agree with Edexcel the measures that should be implemented to address the concerns noted from the monitoring of the centre devised assessments (CDAs).

Ofqual requires the awarding bodies to ensure that future assessments provide appropriate opportunities for the full range of candidates to show what they know, understand and can do.

Ofqual will review future question papers and mark schemes for GCSE science and GCSE additional science to ensure that they are valid and reliable.

For the objective test and objective style question papers, this review will include consideration of:

- the opportunities provided for more able candidates to show what they know, understand and can do
- any factors other than demand that may have affected the difficulty of papers
- the demand of questions in terms of the plausibility of incorrect responses
- the appropriateness of those questions assessing the broader aspects of 'how science works'.

For the structured question papers, this review will include consideration of:

- the opportunities provided for more able candidates to show what they know, understand and can do
- the appropriateness of those questions assessing the broader aspects of 'how science works'.

Ofqual requires the awarding bodies to set grade boundaries so that:

- they can be confident that these are in line with national standards
- standards are maintained as specifications become established.

Ofqual will agree with the awarding bodies the measures necessary to ensure that grade boundaries are set appropriately.

Future specifications

Ofqual recommends revision of the *GCSE criteria for science* and the development of new specifications in these subjects to ensure that:

- different routes to a subject grade, both across and within specifications, are comparable in their requirements

- the weightings of different types of assessment are appropriate, so that candidates across the range are able to demonstrate what they know, understand and can do.

Ofqual recommends that revision of the *GCSE criteria for science* includes consideration of whether the broader aspects of 'how science works' could be more validly assessed through means different to those used currently.

Ofqual requires future specification development to ensure that:

- individual assessments have sufficient scope to discriminate accurately across the full range of candidates' performance
- the mark allocations for individual assessment units are appropriate, so that candidates can be credited reliably for what they know, understand and can do
- the mark allocations for individual assessment units are appropriate, so that candidates across the range are able to demonstrate what they know, understand and can do.

Appendix A: GCSE criteria for science

The revised *GCSE criteria for science*, which relate to the specifications monitored in 2007 and 2008, are provided below.

GCSE CRITERIA FOR SCIENCE

1. INTRODUCTION

- 1.1 These criteria define the subject-specific essentials for GCSE specifications in science subjects. Specifications must also meet the requirements of the regulatory authorities' general requirements, including the Common and GCSE criteria.
- 1.2 Any specification that contains significant elements of the sciences must be consistent with the relevant parts of these criteria, and should appropriately develop students' skills, knowledge and understanding of how science works.

2. AIMS

- 2.1 All specifications should give students opportunities to:
 - develop their interest in, and enthusiasm for, science;
 - develop a critical approach to scientific evidence and methods;
 - acquire and apply skills, knowledge and understanding of how science works and its essential role in society;
 - acquire scientific skills, knowledge and understanding necessary for progression to further learning.

3. SPECIFICATION CONTENT

- 3.1 All specifications should include a rationale which clearly reflects the approach taken within the specification. This approach should include an emphasis on one or more of:
 - evaluating evidence and the implications of science for society;
 - explaining, theorising and modelling in science;
 - procedural and technical knowledge of science practice.
- 3.2 All specifications must specify the skills, knowledge and understanding on which assessment will be based.
- 3.3 All GCSE specifications in science subjects should build appropriately on the knowledge, understanding and skills set out in the National Curriculum key stage 3 science programmes of study for England, Wales and Northern Ireland.
- 3.4 Study of science specifications, either singly or in combination, should provide access to further learning in science-related areas at level 3.
- 3.5 Specifications must present content in a coherent and concise manner which aids teaching, learning and assessment.

- 3.6 Specifications with the title **GCSE Science** should consist of the skills, knowledge and understanding of how science works:
- (i) **data, evidence, theories and explanations**
 - a) the collection and analysis of scientific data
 - b) the interpretation of data, using creative thought, to provide evidence for testing ideas and developing theories
 - c) many phenomena can be explained by developing and using scientific theories, models and ideas
 - d) there are some questions that science cannot currently answer, and some that science cannot address
 - (ii) **practical and enquiry skills**
 - a) planning to test a scientific idea, answer a scientific question, or solve a scientific problem
 - b) collecting data from primary or secondary sources, including the use of ICT sources and tools
 - c) working accurately and safely, individually and with others, when collecting first-hand data
 - d) evaluating methods of data collection, and considering their validity and reliability as evidence
 - (iii) **communication skills**
 - a) recalling, analysing, interpreting, applying and questioning scientific information or ideas
 - b) using both qualitative and quantitative approaches
 - c) presenting information, developing an argument and drawing a conclusion, using scientific, technical and mathematical language, conventions and symbols and ICT tools
 - (iv) **applications and implications of science**
 - a) the use of contemporary scientific and technological developments and their benefits, drawbacks and risks
 - b) how and why decisions about science and technology are made, including those that raise ethical issues, and about the social, economic and environmental effects of such decisions
 - c) how uncertainties in scientific knowledge and scientific ideas change over time and the role of the scientific community in validating these changes.
- 3.7 All specifications with the title **GCSE Science** should set the skills, knowledge and understanding, outlined in paragraph 3.6, entirely in the context of:
- (i) **organisms and health**
 - a) organisms are interdependent and adapted to their environments
 - b) variation within species can lead to evolutionary changes and similarities and differences between species can be measured and classified
 - c) the ways in which organisms function are related to the genes in their cells
 - d) chemical and electrical signals enable body systems to respond to internal and external changes, in order to maintain the body in an optimal state
 - e) human health is affected by a range of environmental and inherited factors, by the use and misuse of drugs and by medical treatments
 - (ii) **chemical and material behaviour**
 - a) chemical change takes place by the rearrangement of atoms in substances
 - b) there are patterns in the chemical reactions between substances
 - c) new materials are made from natural resources by chemical reactions
 - d) the properties of a material determine its uses
 - (iii) **energy, electricity and radiations**
 - a) energy transfers can be measured and their efficiency calculated, which is important in considering the economic costs and environmental effects of energy use
 - b) electrical power is readily transferred and controlled, and can be used in a range of different situations
 - c) radiations, including ionising radiations, can transfer energy
 - d) radiations in the form of waves can be used for communication
 - (iv) **environment, Earth and universe**
 - a) the effects of human activity on the environment can be assessed using living and non-living indicators
 - b) the surface and the atmosphere of the Earth have changed since the Earth's origin and are changing at present
 - c) the solar system is part of the universe, which has changed since its origin and continues to show long-term changes.

- 3.8 The treatment of each area of content in paragraph 3.7 should be similar, or of comparable demand, to the indicative content within Appendix A.
- 3.9 At least half of each specification with the title **GCSE Additional Science** should set the skills, knowledge and understanding, outlined in paragraph 3.6, in the context of the following content. The remainder of each specification should set the skills, knowledge and understanding, outlined in paragraph 3.6, in the context of a balance of further appropriate scientific content.
- (i) **Biology**
- a) **Cells and growth**
Chemical reactions essential for life and growth take place inside cells. Differences between plant and animal cells lead to different patterns of growth and development.
- b) **Energy flow and element cycles**
Plant biomass provides energy and nutrients for other organisms. Through the consumption of organisms and decay, energy flows through the biosphere and chemical elements are recycled within it.
- (ii) **Chemistry**
- a) **Structure and bonding**
The outer electrons of atoms are involved in chemical reactions. The structure and properties of a substance are strongly dependent on the nature of the bonding which results from the forces between the electrons and nuclei of atoms.
- b) **Chemical synthesis**
Raw materials are converted into new and useful substances by chemical reactions. The theoretical yield of a chemical reaction can be calculated.
- (iii) **Physics**
- a) **Forces and motion**
Forces arise from interactions between objects. The balance, or otherwise, of these forces on an object affects its movement. Energy transfers can occur due to these interactions though the total energy remains constant.
- b) **Nuclear changes**
Nuclear changes within unstable atoms cause random emissions of particles. Nuclear changes also cause the emission of energy in the form of useful and dangerous radiation.
- 3.10 The treatment of each area of content in paragraph 3.9 should be similar, or of comparable demand, to the indicative content set out in Appendix B.
- 3.11 Taken together, **GCSE Science** and **GCSE Additional Science** should be equivalent to the GCSE Double Award: Science, offered under the previous GCSE criteria for science. They should, therefore, provide comparable preparation for further study of science at level 3.
- 3.12 All specifications with the title **GCSE Applied Science (Double Award)** should set the skills, knowledge and understanding, outlined in paragraph 3.6, and content in paragraph 3.7, in appropriate vocational contexts. Any additional content selected should provide appropriate vocational contexts.
- 3.13 All specifications with the title **GCSE Additional Applied Science** should develop the skills, knowledge and understanding, outlined in paragraph 3.6, through content selected to provide appropriate vocational contexts.
- 3.14 At least half of each specification with the title **GCSE Biology, GCSE Chemistry** and/or **GCSE Physics** should include the appropriate skills, knowledge and understanding defined in paragraph 3.6, and the content in paragraphs 3.7 and 3.9. The remainder of each specification should consist of further biology, chemistry or physics, as appropriate. Taken together, the three qualifications should cover all the knowledge, skills and areas of content defined in paragraphs 3.6, 3.7 and 3.9.

- 3.15 Specifications in the sciences with other titles should use appropriate content to develop the skills, knowledge and understanding of how science works, outlined in paragraph 3.6.

4. KEY SKILLS

- 4.1 All specifications in the sciences should provide opportunities for developing and generating evidence for assessing the Key Skills listed below. Where appropriate, these opportunities should be directly cross-referenced, at specified level(s), to the criteria listed in Part B of the Key Skills specifications:

- communication
- information and communication technology
- application of number
- improving own learning and performance
- working with others
- problem solving.

5. ASSESSMENT OBJECTIVES

- 5.1 Specifications must require that all candidates demonstrate the following assessment objectives in the context of the prescribed skills, knowledge and understanding. Within the assessment objectives, candidates should be required to use communication skills, including ICT, as specified in 3.6 (iii), using scientific conventions (including chemical equations) and mathematical language (including formulae), where appropriate.

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

Candidates should be able to:

- a) demonstrate knowledge and understanding of the scientific facts, concepts, techniques and terminology in the specification
- b) show understanding of how scientific evidence is collected and its relationship with scientific explanations and theories
- c) show understanding of how scientific knowledge and ideas change over time and how these changes are validated.

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

Candidates should be able to:

- a) apply concepts, develop arguments or draw conclusions related to familiar and unfamiliar situations
- b) plan a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem
- c) show understanding of how decisions about science and technology are made to different situations, including contemporary situations and those raising ethical issues
- d) evaluate the impact of scientific developments or processes on individuals, communities or the environment.

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

Candidates should be able to:

- a) carry out practical tasks safely and skilfully
- b) evaluate the methods they use when collecting first-hand and secondary data

- c) analyse and interpret qualitative and quantitative data from different sources
- d) consider the validity and reliability of data in presenting and justifying conclusions.

6. SCHEMES OF ASSESSMENT

- 6.1.1 All GCSE specifications in the sciences should be unit based.
- 6.1.2 All specifications in the sciences should include a minimum external assessment weighting of 25%.
- 6.1.3 All specifications in the sciences should include a minimum internal assessment weighting of 25%.
- 6.2 Assessment units should have only one form of assessment, ie internal or external.
- 6.3 The assessment objectives listed in Section 5 must be weighted within the following ranges:

Assessment objectives	
AO1: Knowledge and understanding of science and how science works	20-40%
AO2: Application of skills, knowledge and understanding	30-55%
AO3: Practical, enquiry and data-handling skills	20-40%

- 6.5 Attainment on single award qualifications will be reported on an eight-grade scale from A* to G.
- 6.6 Attainment on the GCSE Applied Science (Double Award) will be on a 15-grade scale: A*A*, A*A, AA, AB, BB, BC, CC, CD, DD, DE, EE, EF, FF, FG, and GG.

7. GRADE DESCRIPTIONS

Grade F

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

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

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

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

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

Grade C

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

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

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

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

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

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

Grade A

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

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

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

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

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

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

**INDICATIVE CONTENT FOR GCSE SCIENCE AND
GCSE BIOLOGY/CHEMISTRY/PHYSICS SPECIFICATIONS**

The skills, knowledge and understanding of how science works (paragraph 3.6) should be set in the context of the following four areas of content.

Areas of content <i>(para 3.7 in the criteria)</i>	INDICATIVE CONTENT
3.7 (i) Organisms and health	
a)	To stay alive, organisms need a supply of energy and materials from their surroundings and from the other living organisms there. There is often competition between organisms for resources.
b)	Individuals within a species can have characteristics that promote more successful reproduction and rearing. Over generations, the combined effects of changes to genes, environmental changes and natural selection can produce changes within species, and new species. Systematic study of the similarities and differences between species, and classification of organisms, helps understanding of evolutionary and ecological relationships.
c)	The nucleus of a cell contains chromosomes that carry the genes and control the cell's activity. In sexual reproduction, each parent contributes half the genes. In asexual reproduction, producing clones, all the genes come from one parent. Genetic modification offers possibilities for treatment of diseases and to produce organisms with particular characteristics.
d)	Hormones regulate the functions of organs and cells, for example, the sex organs. Mechanisms, such as blood-clotting or reflex and conscious actions, help safeguard the body.
e)	When new medical treatments are devised, they have to be extensively trialled and tested before being used. The human body has defence mechanisms against the harmful effects of micro-organisms. Medical treatments against diseases caused by these include immunisation and antibiotics. The use and misuse of substances, such as solvents, alcohol, tobacco and other drugs, can affect the normal functioning of body systems, affecting mental as well as physical health.
3.7 (ii) Chemical and material behaviour	
a)	All chemical elements are made up of atoms which consist of nuclei and electrons. Different elements have different properties that relate to the structure of their atoms. Atoms join in different ways to make compounds. No atoms are lost or made in chemical change.
b)	Similar elements or similar compounds react in similar ways. Knowledge of chemical reactions is useful in predicting what will happen in other reactions, and in deciding how to make a new material.
c)	All materials are obtained or made from substances in the Earth's crust, sea or atmosphere or from living things, eg oil and plastics, metals, biomass. The production and disposal of materials can have environmental impacts.
d)	Materials differ in their properties and so are suitable for different purposes. New materials are developed to meet specific requirements, eg 'smart materials', nanotechnology.
3.7 (iii) Energy, electricity and radiations	
a)	Energy transfers can be measured, eg temperature changes, and modified, eg by insulation. Energy use can be costed. The economic and environmental effects of energy use can be compared and evaluated, eg alternative ways of keeping a home at a suitable temperature.
b)	Electricity is transferred from power stations to consumers and is widely used because it can readily transfer energy to devices which produce movement, heating, light and sound.
c)	Electromagnetic radiation can transfer energy from a source to a receiver or detector through a vacuum. When radiation strikes an object, including living material, some energy may pass through it, some may be reflected and some absorbed. Radioactive materials emit ionising radiation all the time.
d)	Radiowaves, microwaves, infra-red and visible light can carry information over large and small distances. Information can be processed to improve the effectiveness of a communication system.

**INDICATIVE CONTENT FOR GCSE SCIENCE AND
GCSE BIOLOGY/CHEMISTRY/PHYSICS SPECIFICATIONS** *(continued)*

Areas of content <i>(para 3.7 in the criteria)</i>	INDICATIVE CONTENT
3.7 (iv) Environment, Earth and universe	
a)	Human activity has measurable effects on the whole biosphere. These are due to population, use of resources, industrial processes, and levels of pollution and waste. Understanding of these effects is based on field measurements of biotic and abiotic factors. Planning is needed at local, regional and global levels to manage sustainability.
b)	Changes in the outer layer of the Earth result from the movement of tectonic plates. This causes slow changes, such as the position of continents and rapid changes, eg volcanic eruptions. The atmosphere originated from gases escaping from the Earth's interior; it has changed as living organisms have evolved.
c)	Exploration of the solar system and the galaxies in the universe can be carried out on the Earth and from space. Current evidence suggests the universe is expanding and that it began with a 'big bang'.

**INDICATIVE CONTENT FOR GCSE ADDITIONAL SCIENCE AND
GCSE BIOLOGY/CHEMISTRY/PHYSICS SPECIFICATIONS**

The skills, knowledge and understanding of how science works (paragraph 3.6) should be set in the context of the following three areas of content.

Areas of content (para 3.9 in the criteria)	INDICATIVE CONTENT
(i)	Biology
a)	<p>The essential chemical reactions of protein synthesis and respiration are catalysed by enzymes inside living cells.</p> <p>Mitosis enables organisms to grow, replace worn out cells and repair damaged tissues. Most animal cells lose the ability to differentiate at an early stage but many plant cells retain it, enabling plants to regenerate from undifferentiated cells in suitable conditions. Animals tend to grow to a finite size whereas many plants are able to grow continuously.</p>
b)	<p>Plants produce biomass by photosynthesis, using carbon dioxide from the air, mineral salts from the soil, and energy from the Sun.</p> <p>Energy released during respiration enables processes to take place inside living organisms. As an organism grows, it takes in chemicals and incorporates elements from these into its own body structure. When it dies, it decays and the elements within it are recycled.</p>
(ii)	Chemistry
a)	<p>Metals conduct because there are relatively free electrons in a giant structure of atoms. When outer electrons are shared with adjacent atoms, strong (covalent) bonds are formed. This can lead to stable molecules (eg O₂, N₂) and hard giant structures (eg diamond). Atoms can lose or gain electrons to form charged ions. The attraction between these results in strong giant structures which conduct when molten or in solution. There are also weak forces between molecules (eg CO₂, iodine and in nanomaterials).</p>
b)	<p>Chemical reactions are of various types, such as oxidation, reduction, neutralisation, precipitation, displacement, polymerisation, electrolysis and thermal decomposition. Reactions can be observed as reversible, and may reach equilibrium. They may also be observed as exothermic or endothermic.</p> <p>The theoretical yield of a chemical reaction can be calculated but the actual yield will almost always be less than this. It is important for sustainable development and for economy to reduce waste and to choose reactions with high yield, high atom economy and non-vigorous conditions (ie low energy consumption and dissipation).</p>
(iii)	Physics
a)	<p>All forces arise from interactions and come in pairs. Motion, including circular motion, can be described using the concepts of velocity and acceleration. The concept of change of momentum can be used to relate an object's motion to the forces acting on it in a particular situation. Applying forces to objects can cause changes in energy (eg stretching a spring or accelerating a car).</p>
b)	<p>Radioactive elements contain unstable atoms that emit radiation from their nuclei as they decay. Some unstable atoms undergo nuclear fission with the emission of a great deal of energy. The nuclei of some atoms can be made to join in the process of nuclear fusion. Fusion is the source of energy release in stars. Background radioactivity originates from minerals in the Earth, from space, and from artificially created radioactive materials.</p>

Appendix B: Schemes of assessment

AQA GCSE Science A (4461)

Unit	Assessment type	Duration	Marks	Weighting
Biology 1a	Objective test	30 mins	36 marks	12.5%
Biology 1b	Objective test	30 mins	36 marks	12.5%
Chemistry 1a	Objective test	30 mins	36 marks	12.5%
Chemistry 1b	Objective test	30 mins	36 marks	12.5%
Physics 1a	Objective test	30 mins	36 marks	12.5%
Physics 1b	Objective test	30 mins	36 marks	12.5%
CAU 1	Centre-assessed unit: ISA + PSA	N/A	40 marks	25%

Candidates must complete the six objective tests and the centre-assessed unit. They are required to submit one ISA in either biology, chemistry or physics.

AQA GCSE Science B (4462)

Unit	Assessment type	Duration	Marks	Weighting
Biology 1	Structured paper	45 mins	45 marks	25%
Chemistry 1	Structured paper	45 mins	45 marks	25%
Physics 1	Structured paper	45 mins	45 marks	25%
CAU 1	Centre-assessed unit: ISA + PSA	N/A	40 marks	25%

Candidates must complete the three structured papers and the centre-assessed unit. They are required to submit one ISA in either biology, chemistry or physics.

AQA GCSE Additional Science (4463)

Unit	Assessment type	Duration	Marks	Weighting
Biology 2	Structured paper	45 mins	45 marks	25%
Chemistry 2	Structured paper	45 mins	45 marks	25%

Physics 2	Structured paper	45 mins	45 marks	25%
CAU 2	Centre-assessed unit: ISA + PSA	N/A	40 marks	25%

Candidates must complete the three structured papers and the centre-assessed unit. They are required to submit one ISA in either biology, chemistry or physics.

Edexcel GCSE Science (2101)

Unit	Assessment type	Duration	Marks	Weighting
Biology 1a	Objective test	20 mins	24 marks	10%
Biology 1b	Objective test	20 mins	24 marks	10%
Chemistry 1a	Objective test	20 mins	24 marks	10%
Chemistry 1b	Objective test	20 mins	24 marks	10%
Physics 1a	Objective test	20 mins	24 marks	10%
Physics 1b	Objective test	20 mins	24 marks	10%
IAA	Internal assessment activities	45 mins each	30 marks each	30%
Practical skills	Non-moderated assessment	N/A	18 marks	10%

Candidates must complete one IAA in each of biology, chemistry and physics, as well as the assessment of practical skills. They must also complete the six objective tests.

Edexcel GCSE Additional Science (2103)

Unit	Assessment type	Duration	Marks	Weighting
Biology 2	Objective test	20 minutes	24 marks	10%
	Structured paper	30 minutes	30 marks	10%
	CDA	N/A	24 marks	10%
Chemistry 2	Objective test	20 minutes	24 marks	10%
	Structured paper	30 minutes	30 marks	10%
	CDA	N/A	24 marks	10%
Physics 2	Objective test	20 minutes	24 marks	10%
	Structured paper	30 minutes	30 marks	10%
	CDA	N/A	24 marks	10%
IAA	Internal assessment activities	45 mins each	30 marks each	30%

Practical skills	Non-moderated assessment	N/A	18 marks	10%
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Candidates must complete one IAA in each of biology, chemistry and physics, as well as the assessment of practical skills. They must also complete two of the three assessment options for each of Biology 2, Chemistry 2 and Physics 2.

OCR GCSE Science A (J630)

Unit	Assessment type	Duration	Marks	Weighting
A211	Objective-style paper (B/C/P)	40 mins	42 marks	16.7%
A212	Objective-style paper (B/C/P)	40 mins	42 marks	16.7%
A213	Objective-style paper (B/C/P)	40 mins	42 marks	16.7%
A214	Structured paper with pre-release material (B/C/P)	45 mins	40 marks	16.7%
A219	Skills assessment: Practical data analysis and case study	N/A	40 marks (16+24)	33.3%

Candidates must complete the four written papers and the skills assessment.

OCR GCSE Additional Science A (J631)

Unit	Assessment type	Duration	Marks	Weighting
A215	Objective-style paper (B/C/P)	40 mins	42 marks	16.7%
A216	Objective-style paper (B/C/P)	40 mins	42 marks	16.7%
A217	Objective-style paper (B/C/P)	40 mins	42 marks	16.7%
A218	Structured paper with pre-release material (B/C/P)	45 mins	40 marks	16.7%
A220	Skills assessment: Practical investigation	N/A	40 marks	33.3%

Candidates must complete the four written papers and the skills assessment.

OCR GCSE Science B (J640)

Unit	Assessment type	Duration	Marks	Weighting
B621	Structured paper (B/C/P)	60 mins	60 marks	33.3%
B622	Structured paper (B/C/P)	60 mins	60 marks	33.3%
B625	Skills assessment: <i>Can-do</i> tasks and report on <i>Science in the news</i>	N/A	60 marks (24+36)	33.3%

Candidates must complete the two written papers and the skills assessment.

OCR GCSE Additional Science B (J641)

Unit	Assessment type	Duration	Marks	Weighting
B623	Structured paper (B/C/P)	60 mins	60 marks	33.3%
B624	Structured paper (B/C/P)	60 mins	60 marks	33.3%
B626	Skills assessment: Research study, data task and practical skills	N/A	60 marks (24+30+6)	33.3%

Candidates must complete the two written papers and the skills assessment.

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