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Applied Science

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Principal Moderator's Report

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Centres are again to be congratulated overall in preparing students well for the units in this award, and, as in previous years, some very high quality work has been produced, enabling candidates to gain good grades.

During moderation, a large number of portfolios are sampled to ensure that standards are maintained and that grades awarded are appropriate and commensurate with the evidence seen.

As a result of examining a wide range of portfolios, some general issues became apparent, where centres and their candidates could approach work differently or more appropriately in order to gain maximum success.

Centres may like to consider their own approaches to the following areas; these are not listed in order of priority or significance since each may or may not contribute to outcomes, depending on current centre practice.

1) Use of the Specification

This may seem a very obvious thing to say but it would seem some candidates show insufficient awareness of the detail of the unit requirements in the specification. The text of the specification describes what students are required to know, understand and undertake. The assessment of portfolios is based on the assessment grids for the unit and again there are required aspects which should be covered. Where candidates cover more aspects than are required (which can sometimes have a detrimental effect on the quality of work produced in the **required** areas) or miss required areas out, this can significantly affect marks awarded.

Hence it is absolutely essential that those responsible for constructing course or unit delivery plans read the specification very carefully, along with the related assessment grids, and ensure that all aspects are covered by candidates. It is also important that candidates are made fully aware of what they are required to cover for the unit and what evidence is required in portfolios to support this. This compliance with unit requirements seems obvious, but each year some candidates demonstrate they are not fully aware of specification requirements based on the evidence seen in portfolios.

Published materials may be used to support delivery of this course and some of these are very good sources of information and ideas. However, centres must be warned that the specification requirements over-ride any published material and careful checking and selection of material is essential. Work must be selected which meets candidates' abilities and meets specification requirements, and so simply following a published book is inappropriate.

At the end of the specification are generic grade descriptors for the requirements of A and E grade standards. Centres should consider these in relation to their own assessments of candidates' work, in conjunction with the grade boundaries for the units which are published

annually in this report, and also in relation to their own school data on predicted student achievement.

2) Terminology used

Accuracy

'Accuracy' is a reference to how close the measured or experimentally determined value of a parameter is to the true value. The true value may be obtained from data books, scientific literature and the like, or, if appropriate, a teacher-determined value could be used as the reference.

Precision

In carrying out experimental work, it is important that the measuring instruments selected are the most appropriate to the task, and lead to readings that can be recorded to suitable levels of precision which, at the same time, keep the percentage errors in the readings to a minimum. Precision is related to the smallest scale division (and occasionally to half a scale division e.g. burette readings) on the measuring instrument used and has implications for the number of significant figures used in the readings taken.

When averaging a number of readings it is inappropriate to record the average value to more significant figures than those used in the original readings.

Precision is also relevant in calculations, especially the final quoted answer. Some candidates seem to have a poor understanding of this and simply copy down their calculator displays, often to far too many significant figures. In other cases, incorrect rounding can lead to final answers being quoted to too few significant figures.

Reliability

Reliability is the extent to which the measurements of a quantity remain consistent over repeated measurements of the same quantity under identical conditions.
An experiment is reliable it if yields consistent results of the same measurement; for instance, concordant titres and consistent repeat values of zones of inhibition.

The results of an investigation may be considered reliable if they can be repeated. If other scientists get the same results, then the results of the initial investigation are more likely to be reliable. The reliability of data within a single investigation can be improved by carrying out repeat measurements.

Repeatability and Reproducibility

Repeatability of results or work refers to the same procedure being carried out by the same person using the same equipment in the same laboratory and getting the same result – if this happens, the experiment is repeatable.
Reproducibility of results or work refers to the same procedure being undertaken by a different person, in a different laboratory with different equipment but yet obtaining the same result.

Validity

Data are only valid if the measurements that have been made are affected by a single **independent variable** only. They are not valid if the investigation is flawed and **control variables** have been allowed to change or there is observer bias. Conclusions are only valid

if they are supported by valid and **reliable** data measured to an appropriate level of **precision**.

(When considering the validity of sources of information, this is a reference to the likelihood that the source used for the information is judged to be one that many would feel they could trust as being an accepted source of information, because it is from a well known and probably long-established authority in the field.)

3) Use of the Portfolio Adviser

The portfolio adviser appointed to a centre is there to help in any query linked to portfolio work or specification requirements. There is *no requirement* to contact the adviser but where a centre tutor or assessor has concerns about delivery of a unit it is best to seek outline guidance about approaches to a unit before starting it, then to put an outline proposal to the adviser for **brief** consideration. Emailed documents are probably best following an initial email enquiry or phone call. Similarly, when assessing completed units it is best to contact the advisor, if it is felt necessary, after making a few trial assessments before seeking help, so that problems can be addressed rather than discussing generic issues.

Portfolio advisers are not in a position to over-mark large numbers of portfolios from centres to 'check' marking. Centres should remember that the adviser is namely that – an adviser – they can explain how to tackle things but cannot guarantee success. That depends on how well the centre and its candidates act on the advice given and the quality or responses candidates make to the work. Centres should not worry about contacting their centre adviser, they are there to help, and a quick email can easily sort out a problem.

4) Preview or student proposals and monitoring of work.

Two areas where centres could improve some aspects of student work are previewing initial plans and interim monitoring of work. Previewing candidates' planned approaches may avert inappropriate work and potential omissions in the early stages of portfolio construction. Similarly, brief monitoring of work during early and mid-stage production can also prevent problems later. This could, for instance, identify inappropriate organisations for SC01, the inclusion of downloaded material, a lack of research in required areas, omissions of aspects of study required by the assessment objectives, and so on.

5) Format of portfolios

AQA does not specify how portfolios should be constructed. However, experience has shown the following points will be of use to candidates:

a) Construction to match specification unit layout aids coverage of the required aspects of study by candidates.

b) Use of sub-headings to match sub-sections in a unit also aids coverage and location of work.

c) Over-large portfolios are problematic. They often take students far too long to produce, make initial marking by the centre assessor very time consuming and make moderation over-long. Production of large portfolios to some extent demonstrates an inability of the candidate to decide what is and is not important and is often a measure of the candidates' Quality of Written Communication (QWC) skills. Double spaced printing, excessive 'white-space' and single sided work also makes portfolios larger than they need be. However, it is also important that portfolios are well laid out and legible, not

micro-print or very dense text. There is a middle way: neat, clear, layout with sufficient content to meet requirements but not so large that relevant material becomes buried in masses of text.

d) It would be very helpful if candidates fully checked their portfolios before submission. Many have duplicated pages by including old and revised sections: to read a page and then find a second revised copy can be frustrating. Similarly, pages out of sequence or inverted also show poor care and attention to details by candidates.

e) Plastic A4 wallets (polypockets), whilst keeping work tidy, make moderation awkward and time consuming. It is best to secure portfolio pages by treasury tags.

f) It was noted this year and in previous years that many candidates do not clearly tabulate raw data from experimental work. A significant number do not make good use of the correct units in tables or on graphs or other display methods. Sometimes conclusions do not match the evidence in the portfolio.

6) Calculations

Many units require candidates to undertake calculations. Candidates should make clear in their portfolios what they are planning to calculate, the formula or formulae to be used should be *briefly* explained and then appropriate data used from experimental work. It should be clear where the numbers used have come from; sometimes moderators are at a loss to see where new numbers have come from. Stages in calculations should be made clear. Some centres provide help-sheets or scaffolding forms for calculations. Whilst these are a great help for some candidates to overcome problems with mathematical work, marks should be awarded appropriately for such work. It should be remembered that more able candidates could have marks limited by giving too much help in this way since they cannot demonstrate autonomy and skill if they have been told exactly what to do. As mentioned previously, the appropriate use of significant figures in calculated values also demonstrates candidates' appreciation of the significance of numbers and their meaning.

7) Autonomy and group work

In some units, group work may be appropriate, especially in SC16 where team work is usual and results are collected for all to use or share. However it is also important that candidates have opportunities to demonstrate their own skills in use of techniques. Inorganic analysis, titrations, preparations, etc. should all be through individual work. A whole group having exactly the same set of titration results, would be considered unusual at GCE level and judgements of skill and autonomy cannot be made fairly. If it is essential to use group data then it is very important for each student to indicate his/her own contributions to the joint effort.

Autonomous working means that candidates, having had the work explained to them, are able to progress relatively unaided. They are still 6th form students and still need to be taught – autonomy does not mean they are left to their own devices, it means that once they have been told what is required, they can progress with relatively little help other than normal teaching.

8) Evaluation

Many candidates do not find this area easy. Some demonstrate confusion – writing the standard procedure in the past tense with comments is not an evaluation.

The purpose of evaluation is to look back at what was undertaken and to consider those aspects which may have presented problems and have possibly contributed to errors in findings. Lack of apparatus or broken equipment are centre problems and, whilst significant and a barrier to student progress, should not feature in an evaluation. (It is expected that candidates will be provided with all the appropriate equipment in sufficient quantities and in working order, that all chemicals and solutions are in the correct concentration or quantities and that sufficient time and laboratory access are provided to undertake their work. Candidates are expected to manage their own time and equipment, etc., but the fundamental requirements for their work should not be a problem for them).

Evaluations should consider the qualitative and quantitative errors associated with the methodology used and measurements made, and this should be in the context of an assessment of the accuracy of the experimental outcomes. The precision of recorded data and its reliability should also be considered. During this section it may be appropriate to consider the effect of variation in results using appropriate statistical methods.

However, candidates should be alert to the appropriate use of statistics in their evaluation. Standard deviation calculations on small numbers of values are pointless, and to calculate values and then not relate them to the experimental results and conclusion is also pointless. Where appropriate, candidates may also wish to calculate errors in equipment and in measurements taken. Many centres encourage candidates to calculate percentage errors but then candidates make little or even no use of the values that have been found, indicating a failure of candidates to appreciate what they have calculated and its significance. (This aspect of evaluation may be included in the data section of the portfolio and be linked to conclusions).

It must be remembered that these detailed mathematical procedures may help able candidates to incorporate further analysis of findings and their impact on conclusions and possible access to higher mark bands. However, for candidates whose mathematical skills may be less well developed, such calculations may detract from other aspects of their work and could actually limit marks. Centres should consider when it is appropriate to encourage candidates to embark on this area of work.

9) Reports

There are two sets of reports all centres should read carefully.

a) One is the set of feedback reports to the centre for each unit they submitted, which are issued at the same time as the results are published. These reports highlight strengths and weaknesses in the last entry and also explain the reasons for any changes in marks that have been found necessary to ensure marking is in line with the accepted AQA standard for each unit. These reports are really very important. It is unfortunate that some centres do not seem to read these (or if they read them take no apparent action) since the same mistakes continue to be made.

b) The second set of reports is that found in the overall examination report for all units and all examined units (this report) which is available on the AQA website at the time of publication of examination results. This report details the overview nationally of each examination component and is a valuable source of information for future entries.

There follows an overview of the Assessment Objectives for this award and then comments on each unit individually.

General Assessment Objective Issues

AO1

The portfolio evidence should encompass all the required elements of study and content detailed in the specification. It is imperative that candidates are aware of the specification's requirements regarding:

- the evidence expected within the portfolio
- the areas where candidates need to demonstrate knowledge and understanding.

Where there are differences between the coverage expected and the actual portfolio evidence provided, then the latter cannot be considered to be comprehensive, extensive or complete, which are typical mark band 4 terms.

For instance, in SC03, the specification requires portfolios to show evidence of (amongst many other ideas) the uses of the analytical techniques, the preparation of standard solutions and the usefulness of combustion reactions; these are common omissions and/or weak areas.

In SC15, the specification gives an extensive list of the aspects of work in the pathology departments that must be considered and in SC10, the list of experimental work required is equally clear.

Other units all have corresponding indications of the extent of portfolio evidence expected and the areas where research is to be carried out. The extent to which knowledge and understanding is demonstrated by candidates can be compared with that required by the specification and matched to the appropriate descriptor in the assessment grids. In SC07, for instance, secondary sources used in research must be checked and validated for mark band 3 and mark band 4, and the necessity for health and safety issues to be considered and a full description of those issues appear in mark band 4, both being frequent weak areas across many centres.

AO2

This Assessment Objective essentially covers the application of scientific knowledge and understanding, and whilst the exact nature of the application may vary from unit to unit, it does encompass calculations (in all units apart from SC01), the application of principles such as bond enthalpies (SC03), food spoilage and preservation (SC04), balanced equations and structures of organic compounds, and types of organic reactions (SC06), quantitative physical relationships (SC10) and ecological survey techniques (SC16).

In calculations, it is each candidate's abilities that are assessed and group work is totally inappropriate in this respect, as is the use of centre directed methods, proformas or tables, etc. Whilst it is expected that the relevant calculation methods are taught and practised, the actual portfolio evidence should be the candidate's own work if marks in the higher mark bands are to be considered. In SC07, for instance, mark band 3 and mark band 4 assume that calculations are independently attempted. Some minor errors in calculations would limit marks as well. It is essential that centre assessors check all calculations (and, please, annotate accordingly, as correct or incorrect).

Precision is also an important factor in calculations, particularly in the precision of the final calculated answer where incorrect or inappropriate rounding should be penalised. The use of correct units is another factor to be considered and penalties applied where necessary. Centres should also note that the performance descriptors for the A/B boundary at A level (pp 185-189 of 2011 specification) indicate that candidates "carry out complex calculations, obtaining correct solutions to an appropriate degree of accuracy". This should be taken into account, for instance, in deciding approaches to SC07 investigations, and subsequently in awarding marks.

AO3(i) and AO3(ii) (Not assessed in SC01)

The levels of the need for teacher involvement in the practical work are part of the assessment grids, and it is expected that centres will annotate portfolios accordingly (as shown by # in the assessment grids). Teacher observations relating to the levels of safe and skilful working, the correct application of standard procedures and risk assessments, should also be recorded. The resulting marks for these aspects of AO3(i) will generally be supported by moderators unless the portfolio evidence contradicts the teacher's assessment. The most common example of this would be where the recorded results indicate that skilful working had not taken place, but there are also occasions where an assessment of 'safe working' and 'adhering to risk assessments' can be compromised by portfolio evidence that includes inappropriate, incomplete or erroneous risk assessments.

Whilst each unit has its own emphasis in AO3(i) and (ii), the clear, logical recording of data, measurements, observations, etc. is common to all, as are the ideas of precision, accuracy and reliability.

It is encouraging that many candidates are aware of the need to present data clearly, to the appropriate levels of precision and with the correct units, but, equally, there are significant numbers of portfolios seen which do not even record all raw data (for instance initial and final burette readings); this is often a centre-wide issue. Similarly, problems with the precision of recording are often centre-based and, despite many previous indications via the annual reports on the examination and feedback to centres, these problems are still relatively common. Examples of typical areas where precision may be weak include titrimetric work (SC03, SC07, and SC12), temperature readings (SC03), and measurement of zones of inhibition in microbiological work (SC07, SC12, and SC16). Whilst the more common problems involve a lack of precision, there are also examples seen of data recorded to apparently too high levels of precision.

There is also a significant degree of variation across the range of centres in terms of the likely errors associated with the practical work that they provide for their students, and this impinges directly on the quality of results obtained and the marks subsequently available in this AO. Tiny titres (around just 1 or 2 cm^3) clearly have large percentage errors, especially if read to just 0.1. In the same way, very small zones of inhibition (a few mm) and small temperature rises (measured only to the nearest degree) are also likely to have large percentage errors associated with them.

Repeats, recognition of anomalies, the calculation of appropriate means, concordance, and a lack of variation or consistency in data are all areas which are very important when assessing the evidence in AO3(i) and a minority of centres seem not to be aware of the significance of such approaches and outcomes in A level practical work. The idea that the candidates' final answers should be accurate (when compared with the expected / data book / literature /

teacher-determined values) is also not considered by some assessors and clearly inaccurate outcomes are not marked appropriately. Unfortunately, it is clear that some very inaccurate student results are sometimes due to errors in making up solutions and a lack of standardisation of those solutions by the centre.

The level of demand of the practical activity is another area that must be considered in this AO. Where the practical work and the results obtained fall short of being 'extensive', 'comprehensive', and 'complete', then marks in mark band 4 will not be appropriate and, depending on the overall lack of demand, depth and breadth, it may be that marks in mark band 1 or mark band 2 will be the best that can be achieved (e.g. in a low level, GCSE-style SC07 investigation).

It is important to reiterate here that the portfolio evidence provides the basis for the mark awarded and, where that evidence is absent, a moderator will find it difficult, if not impossible, to support a high centre mark. Where methods, SPs or other information have to be researched, then this research must be explicit in the portfolio.

As stated above, each unit has its own emphasis in AO3 and the aspects of study assessed do vary, with AO3(ii) for a given unit having some particular strands that may not be common to other units. It is essential that candidates are fully aware of the exact requirements for the unit being studied and that they ensure that they provide portfolio evidence accordingly. However, a common aspect that does challenge most candidates and that is present in most units is the area of evaluation, sometimes leading to modifications to products or methods. Here, it is unlikely that candidates will do well without centre input and teaching. All too often, candidates simply consider their own practical inexperience and often reinforce the ideas that skill levels are very low (and, unfortunately, inconsistent with the high marks awarded by the centre). What is needed in most units is a consideration of the accuracy of the result (see above) followed by a detailed discussion of the quantitative and qualitative errors in the practical work. On this basis, any required modifications will follow quite logically and will provide a foundation in science.

In consideration of marking Assessment Objectives, it must be remembered that as a rule of thumb, approximately 2/3 of the marks (40 of the 60) available are for AO3, which is essentially the practical aspects of the unit (SC01 has no AO3). Hence practical work makes a very significant contribution to the marks a candidate gains and is expected to be of high quality in order to gain high marks. AO1 and 2 contribute approximately 1/3 of the unit marks and whilst this is a required and significant part of the unit, it nevertheless reflects the emphasis that should be placed on the work in units.

COMMENTARY ON INDIVIDUAL UNITS

SC01 Investigating Science at Work

Research methods: candidates are increasingly providing evidence of the use of a wide range of methods and are also incorporating an evaluation of the methods they have used which, whilst not a requirement for this unit, does add to the portfolio evidence for the use of methods. Weaker candidates often simply list a selection of research methods but with no evidence that they were actually used. In some portfolios, there is no evidence of methods used at all.

Survey: unfortunately, some candidates still insist on listing a number of inappropriate organisations where the link to science is tenuous to say the least, and there are no scientifically qualified employees. This has been raised many times in the past, both in previous reports on the examination and in standardisation materials, and centres need to guide candidates carefully in this respect.

Summary: again, this has been mentioned in previous reports, but weaker candidates are still producing poor summaries, particularly as regards the description of the science undertaken at the organisations. This is another area where candidates would benefit from guidance by centres.

The in-depth study of the single organisation: here, the key remains the selection of a suitable organisation that allows access to all the assessment criteria at a suitable level. A degree of centre involvement in this choice is imperative. Similarly, the availability of information is another key factor, but it must be stressed that basic research using the company's website and a visit only is unlikely to identify sufficient content for the portfolio to score well. Very often, candidates have not developed their research skills particularly well at this stage of the course, and they may need some assistance in accessing the additional material needed to move up the mark bands. A case in point would be the "science of the processes" where candidates may miss several key processes entirely or they identify the processes, but do not give any detail or explain the science behind them. For instance, a study of a brewery might consider the more obvious basic processes including fermentation, etc, but would not include all the vital analytical procedures, QA, QC, microbiological work, monitoring of effluent and waste, etc. that accompany them, certainly in a large scale operation.

The importance of getting the science of the processes complete and comprehensive is not just an end in itself, as it enables the important links to the other aspects of study (skills, qualifications, roles, responsibilities, ICT, H&S) to be developed completely and in detail.

Constraints: the concept of commercial and legal constraints is a difficult one for Y12 students to fully appreciate and will require some input from teachers. Sometimes, organisations are reluctant to share commercial information with outsiders, and some degree of lateral thinking and extensive research may be necessary. Again, much depends on the type of organisation selected for study. Just because information may not be directly available from the organisation, it does not mean it can be excluded from the portfolio!

Impacts on the community: the specification is quite clear as to the areas that must be considered and candidates must be made aware of this in order to avoid some of the incomplete sets of portfolio evidence that are sometimes submitted.

SC03 Finding out about Substances

Many centres are delivering this unit very well, with good, realistic vocational scenarios (not a requirement, but in keeping with the applied nature of the course) and objectives. Candidates clearly find that working towards a set objective allows them to analyse data with a purpose in mind and to provide conclusions relating to the original task set. In turn, this then allows them to adopt a context in which to evaluate their findings.

The extensive set of assessment criteria for this unit are well known to the majority of centres, but a small number continue to deliver the five required investigations without full recognition of some aspects of study, leading to omissions and weak areas in the portfolio evidence. Typical examples would include the discussions of the uses of the techniques in the workplace and the usefulness of exothermic/combustion reactions, the limitations of the qualitative techniques and the scientific principles that form the basis of volumetric analysis, colorimetry and chromatography.

Calculations remain variable, but there is evidence that some centres provide too much detailed assistance via complete lists of stages, equations/relationships, grids or methods which require little more of candidates than to substitute numbers and use a calculator. Where this level of teacher or centre-led involvement occurs, portfolios should be annotated accordingly and marks restricted to lower mark bands. Units and precision remain issues for many, and incorrect use of either will limit marks.

In all experiments, the recording of data and measurements must be at the level of precision expected at GCE level. Frequently, however, precision is poor and this should be reflected in the marks awarded. Examples include burette readings which should be to +/- 0.05 and appropriate precision for temperature and mass readings in the enthalpy determination and distances in chromatography. It is equally important for all raw data (e.g. initial and final burette readings) to be recorded.

Reliability is another issue which is important and there should be evidence of repeat readings and concordance.

Accuracy is sometimes more difficult to assess, but it should be possible for centres to identify the expected results for each of the investigations, to annotate the portfolios accordingly, and to mark this aspect appropriately.

A recurring weak area, even for a large proportion of higher scoring candidates, is the evaluation of the experiment. It is an area which needs to be developed as candidates have no previous experience of evaluating A Level science experiments, and much of what is written is really just a comment on the candidates' lack of ability and experience. What should be in evidence is a discussion of the accuracy of the results obtained in comparison with the expected or teacher or data-book value, followed by a consideration of the quantitative and qualitative errors associated with the methodology and results obtained.

SC04 Food Science and Technology

There are still both good and less good approaches to this unit in evidence across a range of centres. This variation is very much a centre issue and centres which pay close attention to the requirements of the specification and Assessment Objectives inevitably produce better portfolios. In AO1, the link between the selected client group, the dietary requirements of that group and initial suggestions (plural!) for products needs to be made clearly and in detail; this also needs to be consistent and logical. One product needs to be chosen and potential recipes researched; a complete 2 or 3 course meal is not a requirement and, if that route is followed, it does compromise the time available for the other aspects of study in this unit - often the investigations into spoilage and preservation. It is still surprising how many products are chosen which have little, if any, connection with the dietary needs of the client group and also how little research into the nutritional levels of this product is evident.

On the subject of research, it was apparent this year that some candidates continue to underestimate the levels of detail required relating to food spoilage and preservation and their background science, especially as these aspects form the basis of the subsequent experimental work. There was also a tendency for the experimental approaches to be minimised by using a combination of both spoilage and preservation methods into a single experimental investigation. This did appear to be centre-driven in a number of cases and may reflect limited laboratory time and resources, but the overall effect was to diminish the breadth and depth of approach. Another effect was that many candidates seemed unaware that both spoilage and preservation should be investigated and that the results should be sufficiently extensive to inform the plan, allow modifications to be suggested and to determine an accurate shelf life. There was also evidence this year that some centres heavily directed this work and such an approach can compromise a candidate's opportunity to show their own skills in this area. Multiple sets of identical results across a range of portfolios raise issues of autonomy and individual skill levels.

SC06 Synthesising Organic Compounds

The account of organic compounds required for AO1 must be based on the requirements of the specification in conjunction with the Assessment Objectives. It is surprising how many candidates still seem unaware of all the required aspects of study and the omissions that result will clearly limit the marks available. Whereas a majority of candidates will cover the required range of functional groups, the detailed consideration of shapes, isomerism, types of reaction and the three designated spectroscopic techniques are too often incomplete and/or lack the levels of detail and range of examples normally expected at GCE level.

Proof reading, checking for mistakes in formulae and structures and the like, also appear to be absent in some cases or only weakly completed and the resulting portfolio evidence lacks scientific accuracy and rigour. That said, there are also examples of outstanding work in this area with full coverage of the required chemistry, accurately presented and clearly explained by the candidate. (Cut and paste, too much centre direction, copies of issued notes, etc. remain a problem in some centres.)

In the experimental sections, there are many good examples of skilful practical work leading to pure samples of two organic compounds prepared with good yields. Centres are reminded that they should provide statements of the levels of safe and skilful working (# in the assessment grids); these statements and the corresponding marks, of course, should be

consistent with the yields obtained and the purity as judged by the melting and boiling points obtained. All data should be recorded clearly in portfolios. As with many units and different types of experimental work, a sensible choice of the two compounds is essential. One solid and one liquid (to allow the melting and boiling points to be measured), compounds which can be prepared in reasonable yield, compounds that can be obtained in a pure state, and experimental methods that allow the skill levels of candidates to be assessed and differentiated, are all key ideas to be considered. Once selected, possible synthetic methods must be researched and this research made explicit in the portfolios.

Good examples of the application of a chosen spectroscopic technique to one of the products made are in evidence, with suitable spectra obtained from data books or the Internet and peaks assigned. The science of the technique is sometimes less well covered indicating a lack of understanding in this area.

SC07 Planning and Carrying out a Scientific Investigation

Many centres have the context of this unit well established and candidates are able to target all the assessment criteria to an appropriate level. This results from a combination of practical methodologies that are suitably demanding for A2 work and produce precise, accurate and reliable results, a realistic client, a set of objectives which is suitable and achievable and a scientific context which allows candidates of all abilities to respond at an appropriate A2 level.

The normal approach to unit 7, which also fits the criteria in the most logical way, is to adopt a linear approach towards meeting the client's objectives using appropriate experimental techniques and following the sequence of researching standard procedures, carrying out trials, modifying the procedures and then applying them to the main part of the investigation. There were a number of approaches seen this year where the "investigation" was, in fact, a combination of a number of short experiments with, it was hoped, a common theme. These generally failed to meet the criteria well and are better avoided. Other problems encountered were those which come from setting an investigation in a context which is too demanding or too low level, either in terms of the scientific background or the practical methodology. Investigations which are simply a sub-set of another unit are also unlikely to be suitable or to generate high marks.

If there is any uncertainty, however small, about the investigation selected, centres are advised to contact their portfolio adviser before commencing work.

Although the following points have been raised many times before, they continue to be weak areas or omissions in portfolios across a range of centres and it is recommended that delivery methods and teaching strategies for this unit are adjusted accordingly.

A believable client is needed – one who needs and wants to know the outcomes of the investigation and who cannot readily access these outcomes him/herself.
Secondary sources should be validated.
The background science to the investigation should be researched in detail, and explained.
Standard procedures should be researched, and included.
Trials are not practice sessions or familiarisation exercises! They are, as the name suggests, trials of researched standard procedures, carried out carefully, perhaps on a small scale,

using the proposed methodology to see if it works or not in the proposed investigation context.
Precision of measurements is a key area.
Reliability, concordance, etc., are key areas.
Calculations are assessed: these should be more than just simplistic and this should be considered when choosing the investigation. Calculated values should be assessed for their "realism" and further analysis of data should be appropriate to the values collected.
The presentation to the client is not the same as the report of the investigation. The presentation must meet the needs of the client, address the original objectives and consider the results obtained.
Many presentations are poorly constructed and lack thought.

SC09 Sports Science

Very good work was produced by candidates who were actively involved in sports (sometimes at national and even international levels) and showed they really understood the scientific background to this unit.

In most cases an individual and a sport were clearly identified – a requirement for all mark bands in AO1 – but too frequently the sport identified was not well chosen and any improvement in performance was difficult to assess.

A sensible 4-week programme of activities was devised by most candidates and this clearly targeted the areas identified for improvement in performance in the chosen sport. However, the links between the training programme and the chosen sport were not well made, especially by lower scoring candidates. This is a key area and aspects of this feature in all Assessment Objectives and all mark bands.

Candidates mostly provided accounts of dietary requirements in relation to the training programme. But for some, their normal diet appeared to be inadequate and the diet for the training programme was also either inadequate or, on occasions, far too much! It was clear that the many candidates saw the link between the needs of the chosen activities and an appropriate diet, and this allowed access to aspects of AO2 and AO3(ii). However it should be noted that a full diet plan is not required. What is required is a clear link between dietary requirements and the chosen training programme and sport.

Many candidates provided evidence of appropriate measurements of bodily physical features or capabilities which were taken at the outset of the programme, using accepted standard measures of fitness with sufficient accuracy and precision to produce values which were reliable. At the end of the programme the same measurements were repeated to enable progress to be determined and appropriate calculations used to determine this. However, it is interesting that despite candidates obtaining sets of measurements, some failed to compare these numerically or undertake calculations on recorded data. Some monitoring of progress through the 4 week programme was evident: some produced a log of activities, others took interim measurements using the same tests throughout the programme. Clear evidence of monitoring can allow access to marks in AO3(ii) from mark bands 3 or 4.

As last year, it was pleasing to see some candidates made judgements of the capabilities of the chosen individual in the selected sport at the start and end of the programme, in addition to the measurements of physical capability. However, a significant number of candidates still

mention a particular sport at the outset and then subsequently it receives no further mention. This is what the programme was meant to be for! Its omission can limit marks.

High scoring candidates included background science at an appropriate level, linked to human performance and linked this to the chosen sport and training programme. Where this is well done, particularly in candidates involved in sport at a high competitive level, high marks in AO1, AO2 and AO3(i) are more easily justified.

The effect of drugs on performance was included by the majority but not all candidates.

A sports injury and an occupation involving science and sport were covered by many candidates, often very well. The best examples – this year, as last year - included an actual injury, reported from real life, and considered an injury sustained by themselves, a close friend or family member where the candidate can talk from real experience, supplemented by research, and provide an account which shows high levels of understanding. Work on first aid was frequently specifically related to the sports injury chosen, and when supported by good background science this work can contribute to high marks. However, many candidates continue to give lengthy accounts of a wide range of sporting injuries and a wide coverage of generic first aid treatment. The specification asks for coverage of 'a sporting injury' not a 'range of injuries'. It is better to cover one in great detail than to cover a range of injuries which are not required. Similarly, whilst it is important to cover the general principles of first aid - to place things in context – it is really important to link the relevant first aid procedures to the sporting injury chosen to be studied.

Unfortunately in the work on this case study of an injury, many candidates resorted to what appeared to be information which had been downloaded from the internet and which had been altered little. This compromised some candidates' marks in these two areas and resulted in mark reduction at moderation. Professional sporting "celebrities'" injuries still appear in many portfolios, and some of these injuries are becoming somewhat historical.

All candidates included work on an occupation related to sport but some chose an occupation where, unfortunately, the scientific nature of the work was minimal. The idea behind this section is for candidates to learn where scientific knowledge and qualifications are used in the work-place, in this case in a sports related field. A sports physiotherapist is frequently chosen and it is appropriate to describe the nature of the work, the qualifications that would be required for the post (or to gain promotion in the area), the career progression, possible salary structure, and very importantly – for this unit – where the scientific knowledge and skills are made use of in the day to day work of a practitioner. In other words, what science does a physiotherapist need to know and how and when do they use it in their work? This is an Applied Science award, and this is an aspect of the application of science in the world of work. Quite frequently the work on a sports-related occupation receives limited coverage.

SC10 Physics of Performance Effects

This is a unit where many centres have a good, well-established approach that has been developed over a number of years. The need to provide evidence of the complete coverage of all the required experiments is understood and, generally, candidates do well on this aspect. The application of the scientific concepts, learnt from the experimental work, to the

lighting and sound plans does vary from portfolio to portfolio, and is often a good indicator of the overall ability of the candidate. These two plans or designs are a very important aspect of the portfolio, and candidates do benefit from guidance in the expected approach to this potentially difficult component.

A detailed consideration of the characteristics of the proposed venue is an essential starting point and should include full consideration of shape and dimensions, and materials used for its construction and furnishings. This can then be used in combination with the background science and experimental results in the determination of the optimum arrangements of equipment for both light and sound systems.

If there is a weaker area, it tends to be the consideration of the sound and lighting systems and effects for the performance attended. Sometimes, a weak choice (often by the centre, not the candidates) of performance leads to just a generalised descriptive approach with little reference to scientific background or to the systems used. Access to the required levels of information (e.g. lighting plans, types of systems used and their arrangements, venue dimensions and characteristics, etc.) can also be a problem and occasions where there is no information whatsoever made available to candidates are not unknown. Candidates are required to cost the lighting set up and lighting effects used in a performance. As a minimum, this should include the running costs of the lighting equipment for the period of the performance, and candidates should be encouraged to consider whether their calculated value is realistic. This may then be extended to include the additional cost of either hiring the lighting equipment or its outright purchase. An overall total should be provided.

SC12 The Actions and Development of Medicines

Some excellent accounts of the action and development of two chosen medicines were in evidence and the best seen were those that targeted medicines that have come into use relatively recently (as opposed to those which have a predominantly historical development). That is not to say that Aspirin and Penicillin cannot score high marks, just that they do not easily lend themselves to discussions of up to date development methods and testing. There were also some of the best sections on formulations ever seen, with each component of a medical product being discussed in great detail in terms of its function and how it aids the administration and action of the medicine.

The practical work, which, of course, carries the majority of the marks, continues to pose problems for candidates across a range of centres. Unfortunately, some rather mediocre results for the analyses and assays (some or all of poor precision, non-concordant titres, tiny titres with, potentially, very large percentage errors, unreliable means, no repeats, very inaccurate final values, etc.) were evident and these were often significantly over-marked by centres.
Candidates in many centres have been instructed well by teachers and had a clear understanding of the importance (and, indeed, meaning) of precision and accuracy. The solutions or samples used had all been carefully standardised where required and this helped candidates to achieve good, accurate results in their analyses.

SC13 Colour Chemistry

This continues to be a unit that is entirely accessible to candidates, but one that requires careful selection of suitable practical work and also careful selection of delivery and teaching methods for certain key areas. As with other units, the portfolio evidence requirements for this unit and the criteria for assessment are clear. Standardisation materials and their commentaries help clarify standards further. Candidates who follow the requirements closely and whose experimental work reaches a high standard will clearly score well.

However, areas where portfolios fall short of the levels needed to access the higher mark bands include a lack of explicit research into the methods for preparation/synthesis of dyes, a summary of those methods and the science underpinning them. There is generally more evidence that the relatively complex chemical concepts behind dye uptake and fastness, including the discussion of intermolecular interactions and forces, and the origins of colour in paint pigments, are being delivered by centres at a higher level and that candidates are demonstrating a greater understanding of these areas.

It does help when the practical work into dye application to fabrics and the hiding power of paint produces extensive results which aid candidates' understanding of these areas and allows a logical and correct application of the background theory. There is increasing evidence of a more detailed approach to these practical areas, with extensive work on wash fastness and detergents, often with colorimetric investigations. Some show a more developed determination of hiding power - for instance, one based on commercial style graduated grids producing semi-quantitative results.

SC15 The Role of the Pathology Service

The work of the four departments should be relatively straightforward for candidates as the specification is very clear in explaining the required aspects of study. Candidates vary far too much in their approaches, however, with a significant number clearly ignoring, or failing to appreciate, the specification and its list of areas of study. Where there was a reasonable attempt to cover the requirements, it was sometimes lacking in detail and, especially, in supporting diagrams and pictorial evidence, which reflected, amongst other things, a lack of detailed research. This area is one where candidates of all abilities can score well and centres are encouraged to develop strategies which result in the complete, detailed accounts that are expected.

In this unit, the two investigations (bioassay and chromatography/electrophoresis) carry a significant number of marks and it is essential that these two practicals demonstrate the breadth and depth expected for an A2 unit. They should be such that they generate extensive data which is precise, accurate and reliable. A simple chromatographic investigation similar to a typical SC03 attempt (i.e. AS level and only one of 5 required experiments in this unit) is unlikely to score well at A2 level where it represents half the practical component for the unit and should be embedded in (a school version of) a standard pathology department investigation. In addition, it would be expected that candidates' practical skills in this area would be more advanced having had previous experience of the technique. Electrophoresis remains a viable alternative, but good examples of school/college based electrophoresis experiments where candidates are fully involved in the practical and produce good quality results are extremely rare.

The bioassays vary significantly from centre to centre, from simple, very limited "one-plate" approaches, demonstrating poor precision and a lack of reliability and restricting candidates to the lower mark bands, to very comprehensive approaches generating extensive sets of reliable, accurate data and well deserved high marks. It would appear that some centres make use of combined results in some of this work. Where large numbers of plates or dilutions are used, this is understandable, but not ideal. If there is any element of group working it must be very clear "who did what" in order for centre marks to be validated and accepted.

SC16 Ecology, Conservation and Recycling

As in previous years, there were some excellent reports of ecological surveys in evidence across a range of possible habitats. Much, of course, depends on the habitat chosen and the time of year when the survey was carried out, and this remains a problem for some centres and their candidates. Equally important is the time allocation for the survey. A small number of candidates did seem to be constrained by this and were unable to collect sufficient data.

The habitat selected and the survey carried out should be consistent with the need to produce extensive biotic data which are used to develop estimates of populations and distributions of organisms/species. Appropriate abiotic data should also be obtained which can then be used to explain these populations and distributions. The data also have to be used to develop food chains and webs and allow energy flows to be considered. A minority of candidates produced so few data that the requirements of the specification and assessment grids could not be met and this usually resulted from the habitat selected and/or the time of year when the survey was carried out. In order to discuss the distribution of organisms in relation to abiotic data it is really important to be able to compare differences between areas. It is not necessary – indeed it is important not to – undertake surveys in two completely different environments.

However, to provide some evidence to support ideas for distributions, it is important to examine different areas in the same habitat. For example, shaded and open areas of grassland, fast and slow or virtually static fresh water, exposed and sheltered shores, low-water/high water zones of the seashore, a transect across sand dunes with a range of changing abiotic conditions. Changing abiotic factors can then be linked to changing species populations. Random quadrats in a single area of similar organisms can certainly allow populations to be estimated but the abiotic factors cannot easily be linked to distributions, other than to describe the status quo.

The origins of the data recorded were not always made clear by the candidate or the centre assessor, and, often, it appeared that secondary data predominated and that the survey was little more than cursory.

The conservation section was frequently well done with a good (often local) habitat selected that has been subject to damage over a period but is now completely re-established or is in the process of being conserved. With the habitat as the central theme, candidates often produced high level work. A more general approach, global problems and studies where the habitat has not been made the central idea often do not generate high marks, so a very careful selection is key.

Work on recycling frequently appears as a lower priority section and is frequently brief. There are three key ideas for this section:

1. What is the local authority policy and practice on refuse collection/recycling? How is this linked to government policies and initiatives?

2. The selection of a chosen material which is recycled by the local authority – what is the "waste-stream" for this material. How is it collected, processed and eventually re-used in some way? Where does it go, who does it and what happens to it?

3. An A2 level consideration of the science behind the recycling process, the economic aspects of the recycling process and the environmental impact of re-processing.