LEVEL 3 CERTIFICATE AND EXTENDED CERTIFICATE

APPLIED SCIENCE

ASC2: Investigating Scientific Techniques
Report on the Examination

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General

Many examples of high quality work were seen in the samples submitted for moderation. Centre assessments were often based on a clear understanding of the specification content and the Performance Criteria, together with an equally good understanding of the depth and breadth of treatment expected for a Level 3 subject.

Many schools/colleges are to be congratulated for ensuring experimental work was suitable, that it worked well, and that it produced appropriate results that allowed students to draw correct conclusions and go on to explain and evaluate the outcomes when required to do so. However, there were examples of weaker experimental work in a small number of cases including experimental approaches that would be below GCSE level. Schools/colleges are urged to rethink approaches which are clearly below Level 3 in standard and/or outcomes, or did not meet the requirements of the specification.

As with summer 2017, the most common problems encountered at the moderation stage included the following:

- Levels of understanding of the depth of knowledge expected to be evident in Level 3 portfolios (especially when Merit and Distinction outcomes are to be considered).
- Levels of understanding of the standards expected in experimental work (eg range of variables, accuracy of data, precision of recording, repeatability/concordancy).
- Standard procedures that had not been fully trialled and generated weak (inaccurate) and sometimes unexpected data, or even no data at all.
- Crediting un-reworded downloaded (cut and paste) content.
- Giving full credit when only part of a performance outcome is met.
- Accepting poor graphical skills and poor presentation of graphs.
- Giving credit for recorded results and/or calculations when templates, ‘scaffolding’ or tables (with headings and units) have been provided
- Using group work in experiments and not identifying individual student’s results.

Some very good examples of internal standardisation by schools/colleges were clearly evident and this enabled schools/colleges confirmation of marks before submission and increased accuracy of assessments. If internal standardisation has not taken place and moderation identifies inconsistent school/college marking, for example across two different teaching groups, then the assessor who is out of tolerance will affect other assessors’ marks. This is because any subsequent regression analysis is carried out on the whole entry.

Schools/colleges are also reminded that the award of Merit outcomes can only be made if the associated Pass has been met, and Distinctions need both the associated Pass and Merit to be met. This is clearly shown in the title row of the performance outcomes grid.

Key points relevant to portfolio construction and content include the following:

- The subject is Level 3 and content should reflect that.
- Whilst direct downloads of text will not receive credit; diagrams, images, tables of data, chemical formulae and structures, equations, and the like are allowed. However, they should be suitably referenced.

  In ASC2, standard procedures (SPs) are normally issued by the school/college and then implemented by students. Therefore it is not necessary for students to re-write SPs or design their own.
- In experimental work, the recorded results have to be consistent with the SP. If results are poor, they must still be recorded. But additional results may be issued in order that the student can go on to meet any associated Merit and Distinction with suitable data to interpret, analyse, evaluate as necessary.

  The minimum evidence will be a table constructed by the student: titles, units, repeats etc; and with some comment indicating what happened and why, if data were not obtained.

  Results recorded by the student are part of the assessment and will provide part of the evidence needed that the student has followed the SP correctly. If data are combined across a number of students' results for good reason, then the contribution of each individual must be indicated via annotation within the portfolio. What is not acceptable is that students are allowed to work in pairs or groups when it is not essential, for instance titrations and determinations of resistivity. Tables of combined results should be the exception, not the rule, and identical results across all experiments and all students are not appropriate.

  In summary, it is each individual student's ability to follow the SP and to record their own results that is assessed in the 6 relevant Pass POs.

Administration, paperwork and presentation

The majority of schools/colleges provided all the required paperwork in support of the students' portfolio evidence, and followed the requirements for the submission of coursework. Where all students used the same Assessment Brief, only one copy is necessary.

For submission, the use of poly-pockets is not acceptable and neither is a loose leaf approach. Schools/colleges should combine all the evidence for PO1–PO4 and secure with a treasury tag to facilitate moderation and prevent loss of pages.

Some schools/colleges enclosed both an initial submission and the final submission. Sometimes this was presented sequentially, and sometimes interleaved. This approach can lead to issues in determining which content should be considered at moderation and which content, if any, is to be ignored. The ability to improve and resubmit is not being assessed and only the final version is important.

Schools/colleges are urged to ensure that portfolios are presented in final version format and in a way that the moderator is presented only with work that is relevant and is not diluted by weaker or even incorrect content elsewhere. Similar approaches to portfolio construction apply to retakes: the final version is what is needed for moderation purposes.

The inclusion of photographs of practical work can provide good evidence, but photographs of graphs often do not, and should be avoided. Graphical skills are assessed in some POs, but an indistinct photograph of a hand drawn graph, often at an angle, may not allow award of credit in some cases. Some 'Excel' graphs also generate issues, sometimes connected with choices of axis scales, sometimes with problems associated with the line of best fit. The use of just basic Excel plotting functions should be reconsidered.

Detailed consideration of the Performance Criteria

PO1 Applied Experimental Techniques in Biology

P1, **M1** and **D1** all require content relating to both respiration and photosynthesis.

- **P1**: an outline of the uses of the measurements of these two processes should include: peak flow, lung capacity for respiration; and yields, productivity in agriculture/horticulture for photosynthesis.
- **M1**: the scientific principles of the relevant measurements should include the equations, descriptions and factors affecting rate of respiration and rate of photosynthesis as indicated in the specification (pages 46, 47), and the principles underlying peak flow, lung capacity and blood pressure.
- **D1**: detailed explanations of how physiological measurements are applied in medical contexts (eg diagnosis, monitoring treatment and recovery), or by sports physiologists, and commercial uses relating to manipulation of factors affecting crop yield and productivity.

For the medical and sports physiologists' applications in D1, reference should be made to normal ranges for measurements and how abnormal data are interpreted and used. High scoring portfolios seen at moderation made good use of diagrams, graphs, tables of data and images to support the written content. As in the summer 2017 submissions, students should be complimented on their research skills, selectivity of content and presentation of the complex scientific ideas involved.

P2, **M2** and **D2** involve various aspects of the experiment to investigate the effect of one factor on rate of respiration. This was done well and the most common approach was that of varying temperature and monitoring respiration of yeast, maggots or germinating seeds.

- **P2**: requires evidence that the student has followed the standard procedure (which may be issued by the school/college), has recorded data which can lead to the rate of respiration, and has clearly identified one factor which was investigated experimentally. This should be an experiment that reflects the Level 3 nature of the award.
- **M2**: sufficient values for the factor investigated must be chosen in order to meet Level 3 expectations. For example, at least five temperatures across a suitable range will be needed if the graphical display of rate against temperature is to allow a full explanation of the effect of temperature on enzyme kinetics. **M2** also needs clear evidence of the use of formulas and calculations to generate values of rate of respiration. The subsequent graph (of rate vs investigated factor values) should be explained in terms of enzyme kinetics with sufficient detail to meet Level 3 demand.
- **D2**: the evaluation must consider both the results obtained and the method (procedure) used. Qualitative errors associated with the method, consideration of the accuracy of the results obtained, and how well they match the expected outcomes can be discussed. Where relevant, anomalies, repeatability, precision of recording, should be considered. Ethical issues should also be considered where relevant.

Simplistic experimental methods giving unreliable, inaccurate results should be avoided.

P3 and **M3** study the Hill reaction, the light dependent reaction of photosynthesis.

- **P3**: clear evidence that the student has followed the standard procedure and recorded results are all that are required.
- **M3**: this was sometimes completed in outline only. Some students just reproduced the original standard procedure with one line slightly amended and no explanation or scientific support. Whilst the modified SP is relevant, so are explanations of how the apparatus is modified, how measurements are made, and also the scientific background to the suggestions made. For instance: ‘How are distance and light intensity related?’, ‘What is the relationship between wavelength and coloured gels?’. Explanations could also be supported with diagrams of modified apparatus as this would aid the reader’s understanding of what is being proposed.

Schools/colleges must ensure it is the light dependent reaction that is studied, not overall photosynthetic rates. As in summer 2017, most students got the reaction to work with few problems and schools/colleges had clearly trialled the experiment well, ensuring satisfactory outcomes.

PO2 Applied Experimental Techniques in Chemistry

P4 and **M4** require both volumetric analysis and colorimetry to be considered. Uses were sometimes a weaker area, especially for colorimetry. There were, however, some very good accounts of the principles of both techniques for **P4** and often sufficient detail to go on and be awarded **M4**. In a small number of cases, the reasons for using one indicator based on correct consideration of pH titration curves and the pH at the end point were clearly established, but they then went on to choose a different (and inappropriate) indicator in the actual experiment.

P5, **M5** and **D3** are all related to a standard titration exercise where the emphasis must be on individual students carrying out the technique, from making up a standard solution through to performing the titration.

Data should include that relating to the preparation of the standard solution (masses of the solid and volume of the volumetric flask). All raw data (including initial and final burette readings) must be recorded to the correct precision (± 0.05 for burette readings and titres) and concordancy should be achieved (two titres within 0.10 cm^3).

Several schools/colleges accepted burette readings to only one decimal place, and a number of students seemed to record the volume of solution in the burette rather than the actual reading (eg 50.00 not 0.00 for instance): neither is acceptable. Some titrations had not been trialled and titres > 50.00 and some < 5.00 were seen.

- **M5**: calculations should be clearly carried out without scaffolding or templates, and include both the preparation of the standard solution and the titration.
- **D3**: good research skills and the ability to combine information from a number of sources will be expected. A range of industrial uses and the need for greater precision and accuracy should be discussed in detail. The use of auto-titrators and auto-pipettes coupled with the use of potentiometric probes and electrode systems to measure the end point are all relevant.

  A comparison of the precision of recording and accuracy achieved between industry and a schools/colleges laboratory can then take place. Also required is a discussion, with examples, of the use of primary standards for a variety of different types of reaction, again with links to ensuring accuracy of outcomes.

P6, **M6**, and **D4** all concern a colorimetric analysis to determine an unknown concentration.

- **P6**: some schools/colleges have only very basic colorimeters, and whilst this is accepted and not an assessment problem, students still have to meet the requirements of the PO grid. With apparatus of limited accuracy, it is even more important to ensure that the range of concentrations used gives the best chance of good results and that correct zeroing with blank solutions is effectively carried out each time.

  It is also important that students record all data (including the absorbance values for the unknown) and go on to determine the concentration of the unknown from the calibration graph.

- **M6**: for the explanation of the choice of filter/wavelength, some experimental data to support the choice is expected. If the number of available filters is restricted, then the process can be demonstrated and explained.

  Inconsistencies (anomalies) in the data recorded were rarely discussed, even when the line of best fit did not go through the origin and there was significant ‘scatter’. Reference to the direct proportionality for abs values < approx 1.0 as predicted by Beer-Lambert was not always made and this then impacted on the evaluation of outcomes that followed.

- **D4**: accuracy was often considered relative to a teacher value, which is acceptable. Percentage errors would be expected at Distinction level, both to support accuracy of the final value, and to allow comments on measurements (solution dilutions, absorbance readings). Repeats, anomalies, line of best fit, should all feature in discussions of reliability, and precision to which measurements are made.

PO3 Applied Experimental Techniques in Physics

P7 and **M7** continue to be objectives that students find to be demanding. A number again found it difficult to distinguish between resistance and resistivity. It was sometimes only in the calculations from experimental results that resistivity was correctly used.

For both resistivity and specific heat capacity, the levels of research into values for common materials and how these values affect their properties (**P7**) and uses in industry (**M7**) were often limited. Few detailed accounts were seen for this section and students should appreciate the need for more extensive research.

Most realised that the specification makes reference to semi-conductors and had a rather brief, often very limited section on this important application of resistivity. As with all Merit and Distinction POs, students should target Level 3 depth and breadth in their portfolio content.

P8, **M8** and **D5** all concern the experimental determination of resistivity of a material.

- **P8**: was well done by most, but some did not include the diameter of the wire in the recorded data, nor did the standard procedure include its determination. The calculation of cross-sectional area was also sometimes missing.
- **M8**: when resistivity was calculated, higher-attaining students were able to go on to compare their value with a researched value for the industry standard. However, the accuracy of the experimental outcomes was sometimes rather low and students found it difficult to account for anomalies in the data when these were very significant. Some also had difficulties in manipulating the units to obtain correct scientific notation and thus make a valid comparison of values.
- **D5**: a challenging task, but good accounts of some methods that may be used in industry were seen. Students clearly had good research skills and levels of understanding of this area of physics. The discussions of levels of accuracy and precision expected and achieved in industry were less well done, and often omitted entirely.

P9, **M9** and **D6** are concerned with the determination of the specific heat capacity of a material. **P9** was generally done well, and very often based on standard apparatus using a 1 kg block and an immersion heater.

- **M9**: specific heat capacity was usually calculated correctly from the data recorded (via a variety of acceptable methods). However, the graphical work seen was, as in summer 2017, often a weaker aspect, with poor choice of axis scales, inappropriate error bars and lines/curves of best fit in many cases. A simple approach to error bars for the temperature values is to use the uncertainty in the measurements made (often ± 0.5 or 1.0). It is not appropriate to apply an overall percentage error, incorporating all measurements made, to just one type of measurement.

  Lines of best fit were sometimes discontinuous (broken) and students seemed determined to draw a straight line even when the points plotted suggested otherwise. It was only a few who realised that the shape of the graph was not necessarily a straight line relationship throughout. As a result explanations of the graph were over-simplified and did not include the expected scientific ideas relating to heat transfer and heat loss.

- **D6**: was often well done, and the solid block/immersion heater approach was adapted for a liquid, heat losses considered, apparatus amended accordingly, and the data to be recorded considered. Those with a suitable diagram of the apparatus tended to find the descriptions easier. It should be noted that **D6** is specifically testing students' abilities to adapt a SP, not research a new one.

PO4 Understand Safety Procedure and Risk Assessment

P10 remains one of the lowest performance areas seen both in this series and in summer 2017. The **P10** assessment is based only on the three student generated RAs, one each for PO1, 2 and 3. The other three RAs can be school/college issued, but should be present in the portfolios and annotated accordingly.

Some students appear to not understand the concepts of 'hazard' and 'risk' which should be applied to each of the entries (eg named chemicals, micro-organism, procedure, apparatus, equipment, etc.). For chemicals, state is important as is concentration for solutions, and separate entries for, say, NaOH(s) and 0.1 M NaOH(aq) would be required. The hazard associated with the entry is then stated and the risk considered. This can then be followed by a consideration of control measures and PPE, disposal and any other relevant comments. 'Glassware' can be considered as one entry, as can 'mains electrical equipment'. A numerical approach to 'hazard' and 'risk' is not appropriate.

Use of statistics

Statistics used in this report may be taken from incomplete processing data. However, this data still gives a true account on how students have performed for each question.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.

Converting Marks into UMS marks

Convert raw marks into Uniform Mark Scale (UMS) marks by using the link below.
UMS conversion calculator