Course Report 2017

Subject	Chemistry
Level	Advanced Higher

The statistics used in this report have been compiled before the completion of any Post Results Services.

This report provides information on the performance of candidates which it is hoped will be useful to teachers, lecturers and assessors in their preparation of candidates for future assessment. It is intended to be constructive and informative and to promote better understanding. It would be helpful to read this report in conjunction with the published assessment documents and marking instructions.

Section 1: Comments on the assessment

Summary of the course assessment

Component 1 — question paper (100 marks)

The question paper consists of two sections totalling 100 marks, comprising a 30 marks objective test, and a 70-mark written assessment formed of short response and extended answer questions.

The question paper performed largely as expected, however, the candidate evidence suggests that the paper was slightly more demanding than in 2016 and, therefore, to ensure consistency, the grade boundaries at upper A, A and C were adjusted downwards.

Component 2 — project (30 marks)

Candidates must undertake a chemistry project that is their own individual work. The project report is externally marked and totals 30 marks.

This component also performed largely as expected and a slight increase in marks was seen this year.

Section 2: Comments on candidate performance

Areas in which candidates performed well

Component 1 — question paper

Section 1 (objective test)

The objective test began with a couple of straightforward questions on orbitals and electronic configuration. Almost all candidates were able to identify the correct answer to Q2, but Q1 proved to be much more challenging than expected.

Other areas where candidates performed well in this section include:

Q3	This was predicted to be a challenging question given that the candidates first had to determine the electronic configuration of the magnesium ion and then produce four quantum numbers. Candidates performed very well in this item and this may be due to the hard work done by centres to familiarise candidates with quantum number.

Q5	Writing the formula for a complex ion involving a negative charge from a name.
Q6	Calculation of the pH of a weak acid. In general, candidates have been good at standard calculations such as these.
Q9	Calculation of a reaction rate using a rate equation and experimental data.
Q10	Normally a demanding question, but candidates were very successful in determining the units of a rate constant from a rate equation.
Q11	Determining the types of bonding and hybridisation found in ethane.
Q13	Stating the definition of a racemic mixture.
Q14	Identifying nucleophiles in the equations for two separate reactions.
Q15	Identifying an organic compound from experimental and physical data.
Q16	Distinguishing between primary, secondary and tertiary amines using boiling point data.
Q17	Identification of an organic compound from experimental results.
Q18	Physical and chemical characteristics of a benzene molecule.
Q21	Classification of a drug.
Q23	Determining the appropriate colour of filter used in a colorimetry experiment.
Q24	Calculation of an R_f value from a diagram of a chromatogram.
Q25	Characteristics of an appropriate solvent used in solvent extraction.
Q26	Suggesting a suitable control experiment in an investigation.
Q29	Calculation of the GFM of a drug from a structural formula and then using this to determine the number of tablets that could be made from 1 mole.
Q30	Identifying a set of data that is both accurate and precise using definitions (provided) of the two terms.

Section 2 (extended response)

This section of the assessment begins with a familiar set of questions involving the context of atomic emission spectroscopy. These were done well by most candidates. Generally, this was the case for all of the calculations in Section 2. Questions 5 and 10(b) are open-ended questions, and traditionally candidates find these quite demanding. Both of these questions were done well by candidates and the most common mark achieved was 2.

Other areas of good performance in this section include:

Q2(a)(ii)	Explaining the effect of an increase in temperature on the value of an equilibrium constant.
Q2(b)(i)	Drawing the shape of an octahedral ion.

Q3(a)(i)(A)	Calculating ΔH is a standard calculation and was done very well by most candidates. Not applying the reaction stoichiometry or writing incorrect units were common errors made by the minority who did not achieve this mark.
Q3(a)(i)(B)	Calculating ΔS is also a standard calculation and was done very well by most candidates. Again, not applying the reaction stoichiometry or writing incorrect units were common errors made by the minority who did not achieve this mark.
Q3(a)(ii)	Calculating the temperature above which a reaction is no longer feasible is a common calculation and was done very well by most candidates. However, a common error made by candidates who did not achieve full marks was to use greater than '>', for example, stating $\Delta G > 0$ rather than $\Delta G = 0$ or $T > 6000$ rather than $T = 6000$ in the final answer.
Q4(a)(i)	Calculating the oxidation number of a metal ion.
Q4(b)(i)	Writing a rate equation given the order with respect to each reactant. A common error made by those who did not achieve this mark was to use an upper-case K instead of a lower-case k.
Q6(b)(iii)(A)	Most candidates were able to identify a desiccator as the appropriate piece of apparatus used to store a sample while cooling.
Q6(b)(iii)(C)	Identifying a possible source of error in an experimental procedure.
Q7(a)(ii)	Selecting an appropriate technique to determine the purity of an organic compound.

Component 2 — project

Most parts of the project were done quite well by candidates. The vast majority of candidates stated an aim and then chose a relevant procedure to achieve that aim. Procedures are generally well described and the majority of candidates achieved the mark for two or more techniques/a modification/a control experiment/standardisation of solutions. Candidates have improved their use of appropriate control experiments. Generally, many candidates achieved at least 4/6 for presenting and processing of results.

Areas which candidates found demanding

Component 1 — question paper

Section 1 (objective test)

Q1	This was planned to be a gentle introduction into the paper, but turned out to be quite demanding for candidates. This was a simple accurate recall about the outermost orbital of noble gases. Most candidates selected response B (a p-orbital). This was not the first time this question has appeared in a paper and so was not expected to have been challenging.

Q6 Choosing an appropriate indicator for a strong acid/weak base titration was not expected to be a challenging question. The question has appeared in different forms on more than one occasion in the past. However, previously, the indicator ranges were given in the question. This time, candidates were expected to look up the ranges in the data booklet. This added complexity to the question and has resulted in an increase in demand. Centres should ensure that candidates are familiar with the contents of the data booklet.

Q19 Candidates struggled to determine the correct number of molecular ion peaks in a mass spectrum due to isotopes present. The molecule in question was a tri-substituted alkane containing isotopes of chlorine. Some candidates thought two isotopes would result in two peaks, some thought that being tri-substituted meant there would be three peaks and some selected the correct answer of four peaks.

Q22 Candidates found questions based on practical techniques particularly challenging. This is a question based on gravimetric analysis and candidates should know that it is required that a precipitate is formed. Some candidates chose response A. This is possibly because silver nitrate was a substance they had heard of not realising that a precipitate would not form. It is essential that candidates have either, experience of the practical techniques or access to details of the practical techniques associated with this course (such as the statements in the Course/Unit Support Notes).

Section 2 (extended answer)

It is worth noting that although many candidates found the following questions to be very demanding, the number who didn't attempt the questions was relatively small.

Many candidates lost one mark by not giving the final answer to the correct number of significant figures. Likewise, a mark was not awarded for writing incorrect units. Candidates should take more care in copying units from the stem of the question should they wish to give them. It is worth reminding candidates that, for most questions, units are not required.

Q2(a)(i) Calculation of an equilibrium constant from data. Most candidates managed to write a correct equilibrium expression, however, many failed to correctly calculate a concentration for PCl_5. Another common error was that many candidates did not realise that, due to the reaction stoichiometry, the concentration of Cl_2 had to be equal to the concentration of PCl_3 (0·0420).

Q2(b)(ii) Most candidates found explaining the difference in the bond angles in two related compounds very difficult. Most attributed the difference to the lone pairs on the oxygen or the higher electronegativity of the oxygen. Very few determined the difference was due to the electron rich double bond (π electrons).

Q3(b) This was a unique question requiring candidates to use physical data to suggest methods of extraction of lead and zinc from a furnace operating at 1200 K. Candidates were expected to give the physical state of the two metals and the method of extraction. Unfortunately, this question did not perform as expected and as a result, the grade boundary at C and A was altered to allow for this.

Q4(a)(ii)	Only a minority of candidates could correctly write the electronic configuration for a vanadium ion in orbital box notation, even allowing for correct follow through from 4(a)(i). Common errors included not labelling the boxes, writing spectroscopic notation or including 4s electrons.
Q6(a)(ii)	A very small proportion of candidates could draw a correct structure for the complex ion. Common errors included connecting four ligands to the copper, drawing Cu – H – N bonds and omitting H atoms when joining Cu to N.
Q6(b)(i)	This was surprisingly poorly done by candidates. It was not expected to be anything other than a straightforward C-grade question. The most common incorrect response given by candidates was ‘condensation’. Neutralisation, although introduced at National 5 level, is still a part of the Advanced Higher course.
Q7(a)(i)	Few candidates could correctly state the procedure used to recrystallise an organic compound. The steps involved are detailed in the Course/Unit Support Notes. Once again, it highlights the importance of candidates having experience of the required practical techniques. Many candidates realised that it was important to use hot solvent and to cool the solution afterwards. What was frequently omitted from the description was to use the **minimum volume of solvent** and/or to **filter the hot solution** to remove the insoluble impurities. Many candidates did mention filtration but only as a way to separate the product after crystallisation was complete.
Q8(b)	Most candidates did not appreciate that restricted rotation can be brought about by ring formation. Many candidates were incorrectly stating that ‘double bonds present in the ring’ were responsible for the creation of the geometric isomers. Most candidates simply stated the definition of *cis* and *trans* isomers related to the structure of the two sugars.
Q8(d)(ii)	This question was poorly done by candidates. Some candidates were clued into H-bonding by the previous question and went on to circle every part of the molecule that could H-bond. Some candidates circled the only remaining amino group. Other candidates circled random groups. Very few circled the only three acceptable groups. This question was deemed non-functioning and the grade boundaries at upper A, A and C were adjusted accordingly.
Q9(a)(ii)	Most candidates simply stated Markovnikov’s rule and made no mention of the stability of the carbocation intermediate. A comparison of the stability of the two possible carbocations was required for this mark.
Q9(b)	Most candidates had not learned the reagent used to bring about this reaction. This was an accurate recall question.
Q9(d)	This was a demanding question. However, following IUPAC naming rules, which the candidates should be familiar with, naming this ether molecule should be within the capability of the candidates.
Q10(a)(iii)	This is another practical technique question in which the candidates did not perform as expected. Most candidates came up with a correct method of confirming the concentration of the permanganate solution (titration,

	standardisation, colorimetry) but did not state that a solution of known concentration should be used in each case. Another common error was to use a (named) base to standardise the permanganate solution.
Q11(a)(i)	Many candidates simply stated that the trimyristin was soluble in ether. This was not an acceptable Advanced Higher response. What was required was either the reason for the solubility (similar polarity), or characteristics of a good solvent for reflux (inert, volatile) which are stated in the Course/Unit Support Notes. Again, candidates need to be familiar with the details of practical techniques.
Q11(b)(ii)	The level of demand was high due to having to apply the (n+1) splitting pattern rule to a skeletal structure. As a result, an adjustment to the C grade boundary was made. Candidates found this a challenging question.

Component 2 — project

Most candidates achieved 2 or 3 marks for the underlying chemistry section of the project. Sometimes the choice of project made it very difficult to gain more than 2 marks since there simply wasn't enough relevant Advanced Higher Chemistry to discuss.

The evaluation is traditionally the most demanding part of the project report. Many candidates find it easier to evaluate the procedures by consideration of uncertainties in equipment and areas where the procedure went wrong, but they find it much more demanding to evaluate the results — quite often, all they supply is a restatement of the findings. It is also common for candidates to attribute large differences between the actual and theoretical/literature values to uncertainties and human error in reading equipment when clearly this is not the case.

Only a minority of candidates referenced their projects appropriately. Guidance on appropriate referencing is given in the 'Instructions for Candidates' document, which every candidate should have access to.

Section 3: Advice for the preparation of future candidates

Component 1 — question paper

Candidates should be encouraged to read each question carefully, including the stem.

Candidates should try to get through Section 1 in around 30 minutes so that they have enough time to complete Section 2 and go back over any questions that they were unsure about.

Candidates should do at least the minimum number of experiments outlined in *Chemistry: A Practical Guide*, which can be downloaded from the Education Scotland website. This will ensure that they have experience of all techniques in the Researching Chemistry unit. This unit tends to be the weak point in the performance of most candidates.

Units are not required in the final answer when they are stated in the stem. If the candidate gives incorrect units, a mark cannot be awarded. They should take care to write the correct units if they wish to include them in the answer. A very common error is to write the incorrect case for the letter k. It is worth pointing out to candidates that they should make a **clear distinction** between their upper- and lower-case letters such as k.

Candidates should consider the number of significant figures in the final calculated answer. For example, it is highly unlikely that a numerical answer to 6 significant figures will be acceptable. Candidates should be taught about significant figures and not to confuse significant figures with the number of decimal places.

It is helpful to go over past paper questions, especially the multiple-choice questions but also Section 2 questions. There is probably no better way to study to pass examinations.

Component 2 — project

General advice

More teacher/tutor involvement at the planning/designing stage would be beneficial to many candidates. However, the planning/designing stage must be the work of individual candidates, and cannot be done as part of a group. This is especially the case when it comes to the experimental stage. Group results are not acceptable.

Unless the centre is presenting a large number of candidates for Advanced Higher Chemistry there is no reason for two candidates from any one centre to be doing the same or similar projects.

Candidates need better advice on writing up the project report. It would appear that not all have seen or used the very useful *Instructions for Candidates* document. A candidate who does a good project but writes it up poorly is likely to score fewer marks than a candidate who does a poor project but writes it up according to the advice given in *Instructions for Candidates*.

Candidates are expected to keep an up-to-date day book or record of work, with entries being checked regularly by their teacher. It is also very helpful to candidates, keeping them in the right direction, making sure they are using controls, carrying out duplicates, etc. It is also very useful when writing up the project report.

It is encouraging to see that teachers are taking on board the advice given at Understanding Standards events, and on the Understanding Standards website.

Writing up the project report

Abstract: The abstract must contain a statement of the aim(s) of the project. Candidates should be advised to keep it simple. Far too many projects have multiple aims stated when only one would have resulted in a better project and write-up, and consequently a better mark.

There is no requirement for a hypothesis in an Advanced Higher Chemistry project report. No mark is awarded for a hypothesis.

Introduction: Although quite often interesting, historical information in the underlying chemistry section will not achieve any additional marks. Marks are awarded for chemistry. Likewise, marks are not awarded for biological information unless it involves chemistry. Given that there is a word count limit on the project report, the allocation would be better spent on the evaluation section than on interesting history and biology.

Procedures: As with a large number of aims, it is also frequently counterproductive to use a large number of samples in the procedure. For example, evidence suggests that analysing one or two types of egg shell or coin or fruit juice is likely to result in a better overall mark than analysing six different types. Again, advice to candidates should be to keep it simple.

Procedures must be described in full, with enough detail to allow another competent Advanced Higher candidate to repeat them. This would involve mentioning, for example, apparatus used, times, temperatures, masses, and concentrations of solutions. Where the technique is one listed in the Researching Chemistry unit, such as a titration, details of how the titration should be physically done need not be given. However, the volumes, concentrations, indicators and colour changes would still be essential. If the technique is not a familiar one, more detailed physical instructions would need to be given.

Procedures should be written in paragraph style, in past tense and impersonal voice. A set of instructions is not acceptable.

If the project involves the determination of one or more compounds, it is not acceptable to simply take it to the nearest university and get IR, UV, NMR etc spectra carried out. It may seem old-fashioned, but the analysis should be done chemically. Spectroscopic data can be used to back up the chemical data.

One of the marks in this section is awarded for any **one** of:

- **Two or more techniques used:** If this mark is to be achieved by using two or more techniques, a good list of techniques is given in the Researching Chemistry part of the Course/Unit Support Notes.

- **Modifications:** If this mark is to be achieved by modification, there must be evidence (raw results) of the procedure being done before the modification was made.

- **Control experiment:** If this mark is to be achieved by performing a control experiment, the results of the control must be used later in the report, eg in the discussion/evaluation. A control experiment is done by using a known mass/concentration of substance to carry out the procedure. This should not be confused with a blank. A blank run is not a control experiment and would not be awarded a mark.

- **Standardisation of solutions:** If this mark is to be achieved by standardisation of solutions, all solutions that are not primary standards must be standardised. Furthermore, the results of the standardisation must be used in the calculation of the final result.

So, it is not necessary to do more than one procedure or technique in the project. Many candidates would do well to concentrate on producing a good project that involves only one experimental technique or procedure. Candidates end up being awarded no marks because they have not described their second procedure properly, or have not given raw results for their second procedure. These are marks which could have been awarded if they had concentrated on the one procedure only and chosen another way of achieving this mark, such as a control experiment.

Likewise, it is not necessary to include a modification.

Although time is a factor, experiments must be repeated where practicable. This is much more than doing a titration until two or three results are concordant. For example, if the project involves determining the fat content of different types of cheese, each experiment should be carried out at least twice for each type of cheese. However, if the project involves a lengthy synthesis, it is not practicable to repeat the whole procedure. In this case, duplication of a melting-point determination or TLC analysis would be sufficient. If nothing has been duplicated in the project, this mark cannot be awarded.

A risk assessment must be included in the project report. Hazards associated with specific chemicals/procedures must be identified or a statement given that no hazards are present. Precautions must be given for each of the hazards identified. If no hazards have been identified, a statement that no extra precautions are needed must be given.

Hazards and precautions must be given for the actual concentrations/masses used in the procedures. Hazard codes, alone, are not acceptable.

Results: Raw results must be given for all experiments. For example, the results of a titration experiment must include initial and final burette readings, not just titre values.

Initial and final masses must also be included for weighing by difference and heating to constant mass.

Candidates frequently use the headings ‘Start (cm^3)’ and ‘End (cm^3)’ in the results table for a titration. These are not acceptable. Headings such as ‘Initial burette reading (cm^3)’ or ‘Final volume (cm^3)’ are acceptable.

Discussion: Candidates should use their results to form a conclusion that is relevant to the aim(s) of the project. There is a tendency by some candidates to add on extra conclusions which are not part of the aim and are not supported by results. This should be discouraged as it invalidates the overall conclusion and the mark cannot be awarded.

Candidates often don’t discuss the positive points of their project and tend to focus on the negatives. However, a discussion of why a procedure was done in a particular way using particular apparatus could be awarded marks in the evaluation. There are 6 marks available in total for evaluation.

One way to achieve a minimum of two marks for evaluation of procedures is to correctly calculate the uncertainties associated with each measurement and then combine them to get the total uncertainty. Most projects involve a measured quantity and therefore this can apply to all of them.

It is common for candidates to state that the difference between experimental and literature values is due to the accuracy of the glassware, and that using class A instead of class B would lessen these differences. It is far better, and more likely to result in credit, to discuss, for example, why a burette was used in the procedure rather than discussing the class of burette used.

For evaluation of results, it is good practice to carry through an overall uncertainty value from evaluation of procedures and calculate the effect it has on the final result.

It may be possible to compare the final result with the manufacturer's stated value or literature value in some projects. Candidates may also compare the result to a control experiment done earlier.

Presentation

Many candidates are not able to properly reference their project report. The three acceptable referencing styles are RSC, Harvard and Vancouver. An example of an acceptable referencing style is given in *Instructions for Candidates*. There are many websites that will create a reference and citation ready for insertion into a report. A Google search will return many of these websites.

Candidates should take care to not exceed the 4950 (4500 + 10%) word count limit. This will result in a penalty of 3 marks being applied to the total mark for the report.

Grade Boundary and Statistical information:

Statistical information: Update on courses

Number of resulted entries in 2016	2614

Number of resulted entries in 2017	2523

Statistical information: Performance of candidates

Distribution of course awards including grade boundaries

Distribution of course awards	%	Cum. %	Number of candidates	Lowest mark
Maximum Mark -				
A	30.1%	30.1%	760	89
B	28.5%	58.6%	718	76
C	24.7%	83.3%	624	63
D	7.0%	90.3%	177	56
No award	9.7%	-	244	-

General commentary on grade boundaries

- While SQA aims to set examinations and create marking instructions which will allow a competent candidate to score a minimum of 50% of the available marks (the notional C boundary) and a well prepared, very competent candidate to score at least 70% of the available marks (the notional A boundary), it is very challenging to get the standard on target every year, in every subject at every level.

- Each year, SQA therefore holds a grade boundary meeting for each subject at each level where it brings together all the information available (statistical and judgemental). The Principal Assessor and SQA Qualifications Manager meet with the relevant SQA Business Manager and Statistician to discuss the evidence and make decisions. The meetings are chaired by members of the management team at SQA.

- The grade boundaries can be adjusted downwards if there is evidence that the exam is more challenging than usual, allowing the pass rate to be unaffected by this circumstance.

- The grade boundaries can be adjusted upwards if there is evidence that the exam is less challenging than usual, allowing the pass rate to be unaffected by this circumstance.

- Where standards are comparable to previous years, similar grade boundaries are maintained.

- An exam paper at a particular level in a subject in one year tends to have a marginally different set of grade boundaries from exam papers in that subject at that level in other years. This is because the particular questions, and the mix of questions, are different. This is also the case for exams set in centres. If SQA has already altered a boundary in a particular year in, say, Higher Chemistry, this does not mean that centres should necessarily alter boundaries in their prelim exam in Higher Chemistry. The two are not that closely related, as they do not contain identical questions.

- SQA's main aim is to be fair to candidates across all subjects and all levels and maintain comparable standards across the years, even as arrangements evolve and change.