External Assessment Report 2015

Subject(s)	Chemistry
Level(s)	Advanced Higher

The statistics used in this report are prior to the outcome of any Post Results Services requests

This report provides information on the performance of candidates which it is hoped will be useful to teachers/lecturers in their preparation of candidates for future examinations. 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 question papers and marking instructions for the examination.

Comments on candidate performance

General comments

As is often the case, the order of questions in Section A was generally Unit 1, followed by Unit 2 then Unit 3.

In Section B, the order of the questions was such that they were intended to become progressively more difficult and, as it happens, candidates certainly did more poorly in the Unit 3, Organic Chemistry, questions.

In general the A-type questions performed as required, although in some of these questions the candidates performed better than had been expected.

Compared to 2014, the candidates performed much better in Section B of the exam and their mean scores in both Section A and in the Investigation report had not changed significantly.

The mean mark in Section A (multiple choice) was 29.4 out of 40 which was slightly better than in 2014 when the mean mark was 29.1. All questions in Section A functioned as expected with the A-type questions scoring significantly lower facility values than the other questions, although question 23 did have a higher facility value (54%) than was expected.

The mean mark in Section B was 33.8 out of 60 and this was much better than in 2014 when the mean mark had been 27.7. This confirmed what markers had stated in their reports. A large majority of candidates managed to complete the paper in the required time.

The mean mark for the Investigation Report was 15.0 out of 25 which was very similar to the mean mark in 2014 (15.1). Again most candidates are submitting well-presented Investigation reports but too few use the Candidate's Guide to their advantage. Centres need to ensure that all their candidates download the most up-to-date version of the candidates' guide from the SQA website. This will be particularly important in 2016 when the Project report will be marked out of 30.

In Section B question 6, there were errors in the values given in the thermochemical cycle. Almost all candidates used the values given in the question paper. A small number commented that the values were different from those in the Data Booklet and some used the Data Booklet values and a very small number used a combination of both sets of values. Markers were given an adapted set of marking instructions so candidates were credited whether they used the values given in the question or the values given in the Data Booklet or a combination of both.

Areas in which candidates performed well

Section A

The following questions in Section A produced high facility values, ie in which 70% or more candidates got the correct answer. The number in brackets is the percentage of candidates getting the correct answer.

Q.1 Knowing that infrared radiation has longer wavelength and lower frequency than visible radiation (80%)

Q.2. The electronic configuration of a krypton atom (92%)

Q.3 Knowing that each line in an emission spectrum results from an excited electron dropping to a lower energy level (91%)

Q.4 Selecting KCl as having the most ionic character (88%)

Q.5 Working out that PH_3 can act as a Lewis base (77%)

Q.6 Knowing that the CH_3^- ion has the same shape as an ammonia molecule (73%)

Q.7 Knowing that silicon can be converted into an n-type semiconductor by doping with arsenic. (90%)

Q.8 Selecting potassium hydride from a list of its properties (80%)

Q.10. Balancing an ion-electron equation (81%)

Q.11 Knowing that the value of the partition coefficient can be altered by changing the temperature. (90%)

Q.13 Realising that nitric acid and sodium nitrate would not make a buffer solution (77%)

Q.15 Hess's law type calculation (83%)

Q.16 Mean bond enthalpy (78%)

Q.17 Knowing that the enthalpy change for the reaction in the equation given was the sum of the hydration energies of potassium and fluoride ions (81%)

Q.18 Knowing that the entropy of a perfect crystal is zero at 0 K (75%)

Q.19 Selecting the correct graph of ΔG^o v Temperature for a reaction which is always feasible. (89%)

Q.20 Knowing that if the position of equilibrium is to the products side then K>1 and ΔG^o<1. (77%)

Q.21 Realising that when $\Delta G^o - \Delta H^o$ is approximately zero that ΔS^o must be approximately zero and selecting the equation representing the reaction with the lowest entropy change (71%)

Q.22 Knowing that the volume is not important when measuring standard electrode potentials (83%)

Q.24 Selecting correct rate equation (71%)

Q.26 Calculating that rate increases by factor of 16 from 20 ^oC to 60 ^oC (73%)

Q.27 Selecting the propagation step in a chain reaction (88%)

Q.28 Selecting the types of organic reactions (81%)

Q.31 Knowing that both boiling point and viscosity increase from propan-1-ol to propan-1,2,3-triol (77%)

Q.33 Working out that propan-1-ol can be oxidised to propanaoic acid and then react with it to form an ester (70%)

Q.35 Knowing that a crystalline derivative should have a sharp melting point (76%)

Q.37 Selecting the substance that exhibits optical isomerism (89%)

Q.38 Knowing that the biggest atom in an organic molecule will be most readily located using X-ray crystallography (71%)

Q.39 Realising that sulphonamides act as agonists (93%)

Section B

In general, calculations were done well except for question 7.

Significant figures are still an issue. Generally speaking, the number of significant figures in the answer should be the same as the quantity in the question with the least number of significant figures. Markers are slightly more generous and will generally accept an answer with one significant figure less up to two significant figures more than the 'correct' answer.

Candidates' performances on questions related to PPAs continue to improve but are still not well done. This will not be relevant in future since there are no PPAs in the CfE course.

Candidates still tend to perform poorly in any question in which they have to 'explain' or 'describe'. It would appear that their ability to perform better in chemistry exams is often limited by their inability to express themselves on paper.

There were high levels of performance in the following questions in Section B, ie parts of questions in which the mean mark of the candidates was at least 70 % of the maximum mark for that part of the question. The number in brackets is the facility value for that part of the question.

Q.1 (a)(ii) 88% of candidates were able to explain why the representation of the electronic configuration of nitrogen given in the question was wrong (88%).

Q.1(b)(i) Calculating the wavelength from the energy (83%).

Q.2(a) Familiar type of question. Calculating ΔH^o (82%).

Q 2(b) Calculating ΔS^o (92%).

Q.2(c) From the results in (a) and (b) calculating the theoretical temperature above which the reaction becomes feasible (76%). Although Q.2 was a familiar type of question, it is encouraging to see such a large number of candidates performing well here.

Q.3(a)(ii) Although only 59% of candidates managed to get part (i) correct, the facility value for part (ii) was 70%. So a large number knew and were able to apply the correct relationship between ΔG^o and E^o. Correct follow through from a wrong answer in (i) got both marks.

Q.3(b)(iv) Realising that when the stopper was removed the $V^{2+}(aq)$ ions are oxidised by the oxygen in the air. This part of the question was answered better than had been expected. (81%)

Q.5(b)(i) Determining numerical values for x and y (initial rates) (79%)

Q.7 This is based on a PPA. However candidates who had not carried out the PPA should have been able to work out the correct answers to part (b). To answer part (a) candidates would need knowledge of the actual PPA. However the calculation in part (b) was not well done. As expected, the facility value for part (i) was high at 77% but the other parts were not well done, even allowing for correct follow through from incorrect answers.

Q.9 (b) The structural formula for the geometric isomer of indigo was well done (83%)

Areas which candidates found demanding

Section A

The following questions in Section A produced low facility values, ie fewer than 50 % of the candidates got the correct answer. Only three questions came into this category:

Q.14 This question was very poorly done. Only 27 % of the candidates got this correct. 49% opted for B. When a strong acid is diluted tenfold the pH value rises by 1. When a weak acid is diluted the pH value rises by approximately 0.5. This can be shown by calculation. This was intended as an A-type question but it did not discriminate well.

Q.32 Another A-type question with low facility value but this one did discriminate well. Only 40% of candidates knew that sodium in ethanol would convert a haloalkane into an ether.

Q.40 Again an A-type question with good discrimination. 45 % of candidates were able to answer that the drug with the structure given could bind to the site only as a hydrogen-bond acceptor.

Section B

The following questions in Section B produced low facility values, ie fewer than 50 % of the candidates got the correct answer.

Q.3(b)(ii) Working out why the yellow solution turned green before it turned blue (24%). Just looking for a mixture of the blue and yellow ions giving a green colour. This question didn't discriminate well, perhaps because too many of the more able candidates were looking for a more complicated answer.

Q.4(b) Naming the oxidising agent in the PPA. The answer, of course, is hydrogen peroxide or H_2O_2 but, unless a candidate has knowledge of the PPA they are unlikely to get the correct answer. (18%) This was an A-type question and it did discriminate well.

Q.5(a)(ii) Explaining whether the forward reaction is endothermic or exothermic. Not good enough to say 'endothermic' on its own. Most candidates worked out that the forward reaction is endothermic but their explanations were poor. (45%)

Q.6(b) Calculating the standard enthalpy of formation of copper(I) chloride. As expected, this performed as an A-type question. (34%)

Q.6(c) Very poorly done (8%). Was intended as an A-type question but answers had very poor explanations. Markers looking for copper(II) chloride is the more stable because it has the **more negative** enthalpy of formation. Answers such as has the 'greater' or 'smaller' enthalpy of formation are too ambiguous. **Definitely worth pointing this out to candidates**.

Q.7(a) As stated earlier, this was a definite PPA type question and only 25% knew that the indicator used in the PPA was phenolphthalein. Some interesting attempts at spelling but as long as it read correctly, the mark was awarded.

Q.7(b)(ii) Calculating the number of moles of excess sodium hydroxide in the **standard flask** (34%). A-type question with good discrimination but, nevertheless, disappointing that so many candidates lost this mark.

Q.7(b)(iii) Only 29% were able to calculate the number of moles of sodium hydroxide which reacted with the acetysalicylic acid. Again a good discriminating question but also disappointing to see so many candidates losing the mark here, despite correct follow through rule being applied.

Q.7(b)(iv) Calculating the mass of acetylsalicylic acid in one aspirin tablet (45%). Not many candidates got the actual correct answer but the correct follow through rule meant many were awarded marks for the correct working here even if their final answer was incorrect.

Q.8(b)(i) candidates needed to get a suitable reagent **and** catalyst correct to get the mark. Had this been out of 2 marks, most candidates would have lost both marks. 29% did get the mark and this worked very well as an A-type question with very good discrimination.

Q.8(c)(i) Drawing the structural formula for 2,4,6–trinitrophenol (35%). Most candidates who got this wrong put NH_2 groups instead of NO_2 on the 2,4,6 positions on the benzene ring.

Q.8(c)(ii) Only 27 % got the formula of the reactive species (NO_2^+) acting on the phenol correct. Getting part(i) wrong made it very difficult to get this mark.

Q.9(a) Another explanation type question. Markers were looking for an answer along the lines of ‘red and green being absorbed and blue being transmitted’. However blue is not being ‘reflected’ and neither is blue light being ‘emitted’ and these were treated as cancelling errors. Again important teaching points for future candidates. Facility value for this part was 20%.

Q.10(c)(ii) Drawing the transition state. Always an A-type question but a commendable 30% got this correct. The 5-membered transition state had to show the bond from the HO to the C and the bond from the C to the Cl as dotted lines and the whole structure should be enclosed in brackets with a negative charge outside the brackets or with a negative charge shown on the central carbon.

Q.10(d) Only 49 % got this correct. Many candidates appeared to be looking for a more complicated isomer and hadn’t realised that the 4th one was simply 1-chlorobutane.

Q.10(e) A creditable 41% managed to work out that 3 peaks would be observed in the proton NMR spectrum of isomer B.

Q.10(f) Definitely an A-type question. The wording in the question was such that the candidates were meant to realise that a different explanation was required for each isomer. The facility value was 29% and with very good discrimination.

Q.11(b) Facility value 34% which was unexpectedly low. As stated in previous years with this type of question, some candidates do not seem to appreciate that compound **X** is the same substance in parts (a), (b) and (c). The major variation this year was that compound **X**

contained sulphur. However the facility value for part (a) was 66% and the empirical formula was also given and so the expectation was that more candidates would get this part correct.

Q.11(c) An A-type question, gathering the information collected in parts (a) and (b) and drawing a structural formula for **X**. Facility value = 37% with good discrimination.

Advice to centres for preparation of future candidates

General

Advise candidates to:

- Read each question carefully including the stem.
- Try to take an average of 1 minute per question in Section A so for the CfE exam, this will be trying to do 30 M/C questions in approximately 30 minutes. This will leave about 2 hours to complete the 70 marks in Section B and to go back over any questions that they were unsure about. The two open-ended questions (OEQs), worth a total of 6 marks, may take some time but candidates should be advised not to spend too much time on these. Around 5 minutes per OEQ is advisable.
- 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 number of decimal places.
- Go over past paper AH Chemistry questions, especially the multiple-choice questions but also Section B questions as well. Teachers should point out to candidates which questions still fit in with the new CfE course. Many questions are still valid but there will not be questions for parts of the new course. The Revised Advanced Higher papers provide a very useful source of suitable questions for practising.
- There are no ½ marks awarded. So if a question is worth 1 mark and the candidate's answer is only partially correct, he/she cannot gain that mark.

Chemistry project

The Project report in CfE AH Chemistry will be marked out of 30 rather than 25 and so the marks per category, in some cases, will be quite different. A new set of guidelines to centres and candidates is available and it is important that candidates download and use the candidates guide from the SQA website.

Points which have been important in the past for Advanced Higher Chemistry Investigations will still be relevant to the Advanced Higher Chemistry Project, and some of these are included below:

- More teacher involvement at the planning/designing stage will be very beneficial to many candidates.
- Candidates should be given good advice on writing up the Project Report.

- 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 the Candidates' Guide.
- It has been obvious in the past that candidates from some centres have been disadvantaged because they have not seen copies of this guidance document. It is also true that some candidates may have been given the guidance document but have chosen to ignore it.
- Many candidates, and presumably their teachers, seem to think it is necessary to use more than one technique in their Investigation. This is not the case, and many candidates would do well just to concentrate on doing a good Investigation which involves only one experimental technique or procedure. In the marking of the Traditional AH Chemistry Investigation reports, candidates often ended up not being awarded marks for not describing their second technique properly or not giving raw results for their second technique. These are marks which would have been awarded if they had concentrated on the one technique only.
- Likewise, it is not necessary, to include a modification. Some modifications are trivial and are just doing what should have been done in the first place.

Other important points include:

- There is absolutely no need for a hypothesis in the AH Chemical Project report. No mark is given for the hypothesis.
- The abstract that follows immediately after the contents page and which contains the aims and summary of main findings should cover all the main points. If the main aim is to determine, say, the vitamin C content of different fruit juices, then the summary of main findings should include the values obtained.
- Since the aim(s) is/are now only stated in the abstract/summary it is important that it is/they are written clearly and is/are easy to understand. Conclusions at the end of the report need to be based on and cover all the aim(s). This is much harder to do if the aim(s) are is/are not stated clearly at the beginning.
- Many candidates do their Investigation experiments without proper controls or replicates. Although time is a factor, ideally, experiments should be repeated completely. 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, then each experiment should be carried out at least twice for each type of cheese. If the project involves determining the vitamin C content of orange juice then the method selected should be tested with a control which should be a solution of ascorbic acid of known concentration to find out how accurate the method is. Results of this could then be discussed in the Evaluation part of the report.
- Raw results should be given. For example, the results of a titration experiment should include initial and final burette readings, not just titre values.
- If the project involves the determination of one or more compounds, then it is not really acceptable to 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 giving the results, observations and conclusions plus reasoning at each stage. If, in addition to the analysis carried out by the candidate, they do get different spectra run then the report should show that the candidate has interpreted the different absorptions correctly and should assign the main peaks correctly.

- Unless the centre is presenting a large number of candidates for AH Chemistry there is no reason for two candidates from any one centre to be doing the same or similar projects.
- Groupwork approaches are not permitted for Advanced Higher Projects.
- Procedures should be clearly described so that they could be repeated by another AH Chemistry student from the information given. Diagrams or photographs often help here. The method(s) used should not be listed as a set of instructions but must be written in the past tense and impersonal voice. The procedure should take into account the need for controls and each experiment should be replicated to eliminate rogue results. Candidates should be aware that any modifications made to original design/method, etc should be reported. This may simply be diluting the titrant to get higher titre values with lower percentage error. However, it is not good enough just to state that a modification has been carried out. The modification should have been made as a result of experience and markers want to see evidence of this. For example, a table of low titre values showing why it was necessary to dilute the titrant.
- When giving raw data, students should ensure that they are recording values with the correct number of significant figures and/or decimal places. Tables should have appropriate headings and correct units should be given. Graphs should also be set out correctly, taking care when using EXCEL and other software that the scales are the most appropriate, major and minor gridlines are included and that lines/curves of best fit are produced. Final calculated results must be calculated to the appropriate number of significant figures. It is easier to understand and therefore better for markers if the results are given after each experiment rather than listed in an Appendix at the back of the report.
- Observations should be recorded, for example, colour changes, precipitates, shapes and colours of crystals, etc. It is most unlikely that any candidate will carry out an Investigation in Advanced Higher Chemistry without observing something that can be mentioned in the report.
- The conclusion(s) must relate to all the aims given earlier and the conclusions should be given under a separate heading in the report.
- The evaluation should also be given under a separate heading near the end of the report. During the evaluation the candidate should not only identify the main sources of error but also show how these affect the final result. Candidates can point out the error values in the measuring equipment used and therefore the uncertainties in each raw and processed result. They can then work through their raw results and calculations to get the uncertainty in their final calculated result. It may then be possible to compare their final result with the manufacturer's stated value in some projects
- Candidates are expected to keep an up-to-date day book or record of work with entries being checked regularly by their teacher. This will be very helpful to the candidate: keeping him/her 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. In the past it has been very evident that some candidates are given a great deal of support in their centres compared to candidates from other centres.

Statistical information: update on Courses

Number of resulted entries in 2014	2393

Number of resulted entries in 2015	2448

Statistical information: Performance of candidates

Distribution of Course awards including grade boundaries

Distribution of Course awards	%	Cum. %	Number of candidates	Lowest mark
Maximum Mark - 125				
A	32.5%	32.5%	796	89
B	22.9%	58.3%	631	75
C	21.7%	80.0%	531	62
D	8.3%	88.2%	202	55
No award	11.8%	-	288	-

For this course, the intention was to set an assessment with grade boundaries at the notional values of 50% for a Grade C and 70% for a Grade A. A 2 mark adjustment was made at the 'A' and upper A boundaries as the question paper was deemed less demanding at the upper end. Q3(b)(iv) and 4(a) were intended to function as 'A' marks but did not function as such.

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.