External Assessment Report 2014

Subject(s)	Chemistry
Level(s)	Revised 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

This is the second year of the revised Advanced Higher exam. In 2013 there were 111 candidates and they performed well in the new exam. This year 262 candidates sat the exam and they also performed well. The main differences in the exam for the revised course compared to the traditional course are:

- Since there are no PPAs in the Revised course then there are no PPA questions in the exam.
- In the revised exam, there are two open-ended questions. Each question is worth 3 marks.
- There are 30 multiple-choice questions and 70 marks in the written section in the revised exam, compared to 40 multiple-choice questions and 60 marks in the written section in the traditional exam.

The mean mark in Section A (multiple-choice) was 23.3 out of 30 compared to 29.1 out of 40 for those sitting the traditional exam. The mean facility value for those questions common to both the revised and traditional exams was 0.77 for the revised and 0.73 for the traditional. Almost all questions in Section A functioned as expected, with the A-type questions scoring significantly lower facility values than the other questions.

The mean mark in Section B was 42.2 out of 70 in the revised exam, compared to 27.7 out of 60 in the traditional exam. The open-ended questions were poorly done compared to other questions, with the mean mark for both being just above 1 out of 3. Most candidates made some effort at these questions with fewer missing them out compared to 2103.

The mean mark in the Investigation was 16.3 out of 25, compared to 15.1 out of 25 for candidates doing the traditional course. The marking instructions were the same for both except that, since there are no PPAs in the revised course, there is no penalty for turning a PPA from the traditional course into an Investigation.

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.

Q1 Knowing that the angular momentum quantum number is the one that specifies the shape of an orbital (70%)

Q2 Knowing that element number 104 in the Periodic Table is a d-block element (89%)

Q4 Realising that a solution which absorbs light only from the UV part of the spectrum is colourless (92%).

Q5 Knowing the Pauli Exclusion Principle (87%).

Q6 Knowing that the energy of electromagnetic radiation is proportional to the frequency (90%).

Q7 Knowing that the intensity of radiation absorbed in absorption spectroscopy increases as the concentration increases. (82%)

Q8 Knowing that SF_6 has bond angles equal to 90^o (70%).

Q9 Working out that BF_3 does not have a pyramidal structure (75%).

Q10 Knowing the electronic configuration of a vanadium atom in its ground state (82%)

Q11 Working out that the highest oxidation state of chlorine is in $HClO_4$. (83%)

Q13 Knowing that the order of a reaction can only be determined by experiment. (71%)

Q14 Working out the rate equation from a suggested mechanism. (74%)

Q15 Knowing that the end-on overlap of two atomic orbitals leads to a sigma bond. (89%)

Q16 Selecting the correct substance which has a geometric isomer. (88%)

Q18 Selecting the tertiary haloalkane from a list of formulae. (95%)

Q19 Knowing that 1-bromopropane changing to propene is an elimination reaction. (93%)

Q20 Selecting the statement that would not be true for both an alcohol and its isomeric ether. (79%)

Q21 Selecting the correct pair of reactants to form ethoxypropane. (71%)

Q24 Selecting the correct structure for a tertiary amine. (90%)

Q25 Knowing that ethene going to ethanol is not a hydrolysis reaction. (89%)

Q26 Selecting the correct compound from its mass spectrum. (79%)

Q27 Knowing that infra-red spectroscopy depends on vibrations within molecules. (80%)

Q29 Realising that a tertiary amine shows no infra-red absorption between 3300 and 3500 cm^{-1}. (90%)

Q30 Selecting the correct active antibacterial agent from its structural formula. (82%)

Section B

Calculations in Section B were not done particularly well. Significant figures are 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.

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.

Section B was prepared with the intention of the more difficult questions being nearer the end of the paper.

Q1(a)(i) Despite this being an 'explain' type question, most candidates managed to get good marks explaining how a line of red light is produced in the emission spectrum of helium. (80%)

Q1(a)(ii)	Calculating energy associated from a wavelength. (84%)
Q1(b)	Knowing the 4 quantum numbers describing the electrons in helium. (92%)
Q1(c)(i)	Writing the electronic configuration for a phosphorus atom using orbital box notation. (91%)
Q1(c)(ii)	Showing that the previous answer is consistent with Hund's rule. (74%)
Q1(c)(iii)	Writing the four quantum numbers describing the excited electron in a phosphorus atom. (74%)
Q2(a)	Drawing the structural formula of oxalic acid given its molecular formula. (87%)
Q2(b)	Calculating the value of x in $CaSO_4.xH_2O$. (71%)
Q2(c)	Calculating the concentration of NaOH(aq) from titration results. (71%)
Q3(a)(i)	Calculating ΔH^o. (73%)
Q3(a)(ii)	Calculating ΔS^o. (72%)
Q3(b)	Using $T = \Delta H^o / \Delta S^o$ to calculate the maximum temperature above which the reaction would no longer be feasible. (77%)
Q5(a)	Drawing the structural formula for ethoxyethane. (89%)
Q5(b)	Knowing that a separating funnel would be used to separate two immiscible layers. (72%)
Q5(c)	Calculating the equilibrium constant. (72%)
Q6(c)	Knowing that electrophilic substitution is the name of the type of reaction when benzene reacts to form methylbenzene. (74%)
Q7(a)	Recognising an antagonist from a description. (91%)
Q7(b)(i)	Drawing the structural formula for 2-hydroxybenzoic acid. (72%)
Q8(b)(i)	Drawing the structural formula for the product of the reaction between HCl and propenal. (79%)
Q9(a)	Circling the chiral centre in ibuprofen. (86%)
Q9(b)(ii)	Suggesting a reason for the yield being less than 100%. (83%)
Q11(a)	Determining the order of reaction with respect to $CH_3CHIC_2H_5$ (80%) and OH^- (74%).
Q11(b)(i)	Writing the rate equation for the reaction. (83%)

Areas which candidates found demanding

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

Q12	Adding more of one solvent to 2 miscible liquids in equilibrium. (46%)
Q37	Working out which fragment in mass spectrometry has a mass/charge ratio of 92. (49%)

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

Q4	Open-ended question on what a student might do to determine if an inorganic substance was 'brand-new'. Some good efforts here but mostly drawing from analytical techniques covered in organic chemistry. Any student who had

	done an Investigation identifying an unknown may have had an advantage here. The mean mark was 1.4 out of 3.
Q6	Knowing which reagent is required to convert benzene into methylbenzene. Maybe some candidates are unsure of the word 'reagent'. (44%)
Q8(a)(i) & (ii)	Performed as an A-type question. (33% for both)
Q9(b)(i)	Also performed as an A-type question. Most candidates realised that compound A was the impurity but didn't appreciate that ibuprofen would also be there and so lost the mark because their explanation wasn't valid. (37%)
Q9(b)(iii)	Difficult question. Candidates had to suggest how compound B could be converted into ibuprofen. Those who got it correct worked out that an extra carbon had to be added so realised that they had to start by making a nitrile. The mean mark here was a creditable 0.76 out of 2 so worked as an A-type question.
Q10	The second open-ended question. Candidates were given the structure of domoic acid and had to suggest how it could be isolated and identified. Again some very good answers but the mean mark was 1.2 out of 3.
Q11(d)	Candidates who had the wrong mechanism were always going to find this difficult/impossible to answer and even those who got the mechanism correct had problems here. Not an easy mark to get and well done the 23% who got this correct.
Q12(a)(i)	Calculating the % of silver in a coin. (44%).
Q12(b)	Calculating the % of copper in a coin (41%).
Q13(a)(i)	This mark was expected to have been gained by more candidates. Too many didn't appreciate that the total volume was now 60 cm^3. (31%)
Q13(a)(ii)	As expected, this was poorly done. (16%)
Q12(b)	Candidates always find questions on buffer solutions difficult. The question performed as expected. (40%)

Advice to centres for preparation of future candidates

General

Advise candidates to:

- Read each question carefully, including the stem.
- Try to get through Section A in about 35 minutes so that they have enough time to complete Section B and go back over any questions that they were unsure about.
- Spend no more than 5 minutes on each open-ended question so that they have enough time to complete all the questions. If time permits they can always go back over their answers to these questions at the end of the exam.
- 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 questions, especially the multiple-choice questions but also Section B questions as well. There is probably no better way to study to pass examinations.

Chemical Investigation

The comments from previous years are still very relevant and are repeated below. The first comment is, again, the most important.

More teacher involvement at the planning/designing stage would be very beneficial to many candidates. Candidates also need better advice on writing up the Investigation Report. It would appear that not all have seen or have not used copies of the very useful Candidates' Guide.

A candidate who does a good Investigation but writes it up poorly is likely to score fewer marks than a candidate who does a poor investigation but writes it up according to the advice given in the Candidates' Guide. It is obvious that candidates from some centres are being 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. Copies of the *Advanced Higher Chemistry Investigation Guidance* can be downloaded from SQA's website. Candidates should be told to follow the methods of citing and listing references exactly.

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 that involves only one experimental technique or procedure. Candidates end 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.

The new additions to the Candidates' guide in 2012–13 are still in the current Candidates' guide, and include:

In Underlying Chemistry: *Downloading directly from the internet or copying directly from books may suggest to the marker that you have not understood the chemistry involved and may be considered as plagiarism. It is always best to put things into your own words*.

In Procedures part (c): *For example, you may have had to dilute a solution to get better titration results. In this and in similar situations you should give the original raw results, where, practicable as well as the results after the modification. It will not count as a modification if you are carrying out the procedure wrongly to begin with and the modification involves carrying out the procedure the way it should have been done to begin with. For example, measuring out a volume for titration using a measuring cylinder then changing to using a pipette, when you should have been using a pipette to begin with.*

In the Results section, *If you are using a weighing bottle when measuring out the mass of reactant, you should record all the masses. If you tare the balance to zero when weighing*

you should state this in your report so that the marker appreciates that you have done so and will not be looking for raw results but just the mass of reactant used.

Other important points include:

- There is absolutely no need for a hypothesis in the AH Chemical Investigation 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 aims are only stated in the abstract/summary, it is important that 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 aims. This is much harder to do if the aims 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 Investigation 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 Investigation 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 Investigation 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 the candidate does 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 Revised AH Chemistry, there is no reason for two candidates from any one centre to be doing the same or similar Investigations.

The second category is for underlying chemistry. There is no need to re-state the aim here. Up to 4 marks are awarded for underlying chemistry. Very few candidates get all 4 marks. Candidates should use this opportunity to show how much chemistry they have found out. Appropriate formulae, equations etc should be given here, especially if relevant to Revised Advanced Higher Chemistry or something covered in Higher Chemistry. It is important that candidates do not simply cut and paste from websites but attempt to write in their own words to show their understanding of the chemistry involved. As stated above, the underlying chemistry is worth 4 marks out of the total of 25 marks for the Investigation.

Procedures should be clearly described so that they could be repeated by another Revised AH Chemistry student from the information given. Labelled diagrams or photographs often help here. The method 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.

Many centres are under the false impression that candidates need to use more than one technique. This is not so. It is just one way of gaining the mark in category 2(c) of the marking instructions. Other ways of getting the same mark include making a modification as a result of experience or doing a control experiment

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 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 Revised Advanced Higher Chemistry without observing something that can be mentioned in the report.

The conclusion(s) at the end must relate to all the aims given earlier and the conclusions should be given under a separate heading near the end of 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 Investigations. The evaluation is worth 4 marks and is very discriminating. Most candidates get only 2 out of 4 here.

To get the final bonus mark, candidates must produce a very good report and have scored at least 3 out of 4 marks in both underlying chemistry and evaluation categories.

Candidates are expected to keep an up-to-date day book or record of work with entries being checked regularly by their teacher. This is a requirement for the internal assessment of the Unit and will need to be available if the centre is selected by SQA for verification of the

Investigation Unit. It is also 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 Investigation report. It is 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 2013	111

Number of resulted entries in 2014	278

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	38.1%	38.1%	106	87
B	29.5%	67.6%	82	74
C	13.7%	81.3%	38	61
D	6.5%	87.8%	18	54
No award	12.2%	-	34	-

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.