External Assessment Report 2013

Subject(s)	Chemistry
Level(s)	Revised Advanced Higher

The statistics used in this report are pre-appeal.

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

There were 111 candidates and they performed well in the new exam. This was to be expected since their average prior attainment was higher than the candidates sitting the unrevised (traditional) exam.

One concern is that some candidates seemed to have difficulty finishing the paper. Comparing the external assessment for the revised course with the traditional course, there are probably two main factors why candidates may have run out of time.

- There are two open-ended questions. Each question is worth 3 marks. Candidates should spend no more than 5 minutes on each question.
- 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. It usually takes longer to get a mark in the written part of the paper compared to the multiple choice section.

The mean mark in Section A (multiple choice) was 21·4 out of 30 compared to 28·0 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 identical. 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 39·0 out of 70 in the revised exam compared to 33·5 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 about 1 out of 3. Some candidates missed out these questions, perhaps with the intention of returning to them later.

The mean mark in the Investigation was 16·7 out of 25 compared to 15·2 out of 25 for those candidates doing the traditional course. The marking instructions were the same for both except that, since there are no PPAs in the revised course, candidates did not lose marks for simply turning a PPA 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 Selecting the correct equation representing the 2nd ionisation energy of a diatomic element (88%).

Q2 Knowing the types of electromagnetic radiation in order of increasing frequency (75%).

Q3 Choosing the correct metal salt which would emit radiation of highest frequency when placed in a Bunsen flame (75%). This question was answered much better than expected and candidates certainly did better than the pre-test results had predicted.

Q5 Hund's rule (81%).

Q8 Identifying the molecule with the largest number of electron pairs (72%).

Q10 Oxidation states of copper in different compounds (71%).

Q13 Shifting the position of equilibrium in phosphoric acid (83%).

Q14 Knowing that the value of equilibrium constant is temperature dependent (90%).

Q15 Calculating a value for the equilibrium constant. (83%).

Q16 Knowing that $[H^+]$ decreases when ethanoic acid is diluted (70%).

Q17 Appreciating that ethanoate ions react with hydrogen ions (74%).

Q18 Selecting the appropriate indicator (71%).

Q21 Recrystallisation as a means of purifying benzoic acid (85%).

Q22 Realising that butanoic acid going to butan-1-ol is reduction (87%).

Q23 Selecting correct types of reactions in an organic reaction sequence (84%).

Q24 Choosing the correct intermediate in the reaction between propene and bromine (73%).

Q25 Knowing that alcohols have higher boiling points (81%).

Q29 Knowing that receptors are usually protein molecules (94%).

Section B

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.

Q1(a) Knowing what 'degenerate' means with respect to orbitals (83%).

Q1(b) Drawing the electronic configuration of carbon in orbital box notation (95%).

Q2(a) Calculating ΔS^o from a table of values (82%).

Q4(c) Calculating percentage of manganese in steel (74%).

Q5(a) Co-ordination number (76%).

Q5(c)(i) Naming the complex ion (76%).

Q6(a) Calculating the pH of 0.10 mol l^{-1} propanoic acid (75%).

Q7(a) Writing the molecular formula from the structure of 2,3-dimethylpyrazine (79%).

Q7(d) Identifying an 'agonist' from given properties (83%).

Q8(a) Calculating order of reaction (78%).

Q8(b) Writing the rate equation (74%).

Q8(c) Calculating a value for the rate constant including the units (70%).

Q10(c) Drawing a structural formula for the product X in a reaction sequence (76%).

Q11(b)(i) Calculating the percentage yield in a chemical reaction (72%).

Q11(b)(ii) Giving a reason for the yield not being 100% (70%).

Q12(b) Using the data booklet to find the bond responsible for the peak at 1140 cm^{-1} in the infra-red spectrum (79%).

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.

Q20 Determining which chloride will have the greatest entropy at 750 ^{o}C (47%).

Section B

The following questions in Section B proved to be difficult, ie parts of questions in which the mean mark of the candidates was lower than 50% of the maximum mark for that part of the question.

Q 1(c) Explaining hybridisation (49%). Nevertheless this was a good effort for an A-type question.

Q3 An open-ended question on pH (34%).

Q4(a) Data required for a calibration curve (31%).

Q5(b) This calculation proved to be very difficult for most candidates (34%).

Q5(d)(ii) Explaining why the absorbance peaks of the complex with ammonia molecules as ligands are at shorter wavelengths (49%).

Q6(b) Calculating the pH of a buffer solution (47%).

Q8(d) Knowing and explaining why the tertiary isomer would have been used. The answer markers were looking for was a correct explanation in terms of the stability of the carbocation (20%).

Q8(e) Outlining the mechanism for an S_N1 reaction using curly arrow notation (44%).

Q9(b) Outlining how to prepare a standard solution (30%).

Q9(c) Diluting a standard solution accurately (32%).

Q11(a) Suggesting a suitable dehydrating agent (38%).

Q11(c) An open-ended question on establishing a product as cyclohexanone (31%).

Q12(a) Only 37% of candidates were able to calculate the empirical formula correctly.

Q12(c) 44% of candidates correctly deduced the molecular formula as $C_4H_{10}O$.

Q12(d) Deducing the structural formula for compound A (24%). Too many candidates treated each part of this question as if it were a different compound A each time. However it was also thought that some candidates failed to reach this question with enough time to answer it properly.

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.
- For questions such as Q14 in Section B of this year's exam paper, candidates need to be able to firstly calculate the C and H content then the oxygen content by subtraction

before calculating the empirical formula. The molecular formula will either be the same as or a multiple of the empirical formula. The final answer must be consistent with answers to earlier parts of the question.

- Go over past paper questions, especially the multiple-choice questions but also Section B questions as well.

Chemical Investigation

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 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 exactly the methods of citing and listing references.

In the revised course there are no PPAs and so it is acceptable for a candidate to take what was previously a PPA experiment and expand it into an Investigation without penalty. Since this is the only change from the traditional AH course, the following is mainly a copy of the external assessment report for the traditional course.

New additions to the Candidates' guide in 2012/13 included:

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 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 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 the aim/all of the aims. This is much harder to do if the aim(s) 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 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 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 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 AH Chemistry student from the information given. 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 appear to be under the 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 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 2012	-

Number of resulted entries in 2013	111

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	35.1%	35.1%	39	85
B	30.6%	65.8%	34	72
C	17.1%	82.9%	19	60
D	6.3%	89.2%	7	54
No award	10.8%	100.0%	12	-

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.