External Assessment Report 2013

Subject(s)	Chemistry (Revised)
Level(s)	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

The 2013 Revised Higher paper followed closely the distribution of marks given in the Arrangements documents as used in the 2012 and Specimen papers.

For teachers used to preparing candidates for the traditional examination, it is worth remembering that there are significant differences in the assessments for the two courses. The revised Chemistry paper places far greater emphasis on assessing a candidate's ability to explain the underlying chemistry and consequently there are greater numbers of marks assigned for extended answers. The revised course places significant emphasis on the development of numeracy skills and, in addition to the standard types of well-rehearsed chemical problems found in the traditional examination, the revised paper also contains a number of questions assessing general numeracy skills within less familiar chemical contexts. In considering the marking of candidate papers it should also be remembered that, unlike in the exam for the traditional course, half-marks are not used in the marking instructions.

To ensure parity between the traditional and revised Higher courses, a benchmarking approach is used in which significant numbers of questions are common to both the traditional and revised examinations to allow the relative strengths of the two cohorts to be accurately gauged. In the 2013 examinations, 20 of the 30 questions in Section A of the revised examination, and questions worth 26 marks in Section B of the revised examination were common to both papers.

This session, the number of candidates presented for the revised Higher more than doubled. Many of the centres presenting candidates for this examination for this year bring, from the traditional course, long standing patterns of larger than average numbers of presentations with both pass rates and proportions of A grades well above the national average. The strength of the cohort presented for the Revised Higher examination was clearly evident in their responses to the benchmarked questions. In questions common to both the traditional and revised papers, the revised cohort consistently outperformed the traditional group.

In general, candidates appeared exceptionally well prepared for the examination with knowledge of the new content introduced in this course being well understood. Most centres appeared to have taken considerable care to cover the different types of questions to be found in the new examination and, in general, candidates clearly understood what was being asked demonstrating good examination technique.

The overall impression of the paper from feedback received was that it that the Revised Chemistry paper was fair but challenging. Markers' reports indicated that candidates generally had no difficulty completing the paper in the time available. Whilst the overall level of difficulty of the questions in this paper were very similar to last year, the marking instructions for the A-type questions of the 2013 paper were made more exacting to bring the A and B grade boundaries closer to the notional values of 60 and 70.

Areas in which candidates performed well

The following Questions in Section A produced high facility values.

Question 1	Definition of Electronegativity
Question 7	Periodic trends in behaviour as oxidising / reducing agents
Question 8	Isomers and homologous series
Question 9	Formula of a carboxylic acid
Question 10	Naming an ester from a shortened structural formula
Question 11	Names of functional groups involved in esterification
Question 12	Melting points of edible oils
Question 15	Denaturing of proteins
Question 19	Identification of isoprene units in a terpene
Question 22	Changes in rates of forward and reverse reactions over time for systems at dynamic equilibrium
Question 30	Designing an experimental procedure

In Section B, markers were particularly struck by the general quality of answers given for questions requiring candidates to write an explanation. Reports submitted by markers who had marked both traditional and revised papers commented on the better clarity and greater depth of detail in the revised cohort's responses to the two 'explain clearly' type questions common to both papers (Question 1(a)(ii) and 3(a)).

Other questions in which candidates performed particular well are listed below.

Question 1(b)	This problem solving question was well answered. Candidates were able to apply their knowledge of condensation reactions in a context they were unlikely to have encountered before.
Question 2(a)	Candidates had a good understanding of why some substances are known as free radical scavengers.
Question 4(b)(ii)	Almost all candidates could draw a structural formula for glycerol.
Question 4(c)	This type of question assesses a candidate's ability to apply good numeracy skills in an unfamiliar chemical context. Responses to this question indicated that most pupils were well prepared, laying out their working very clearly.
Question 5(a)	This atom economy calculation was particularly well done showing that candidates had been well prepared for the types of chemical calculations new to the revised Higher course.

Question 5(b)	This percentage yield calculation was generally very well done. Whilst the majority of candidates solved this by first calculating the theoretical yield in grams and then using a formula such as 'percentage yield = (actual yield ÷ theoretical yield) $\times$100', an increasing number of candidates successfully answer this type of question by calculating the number of moles of reactant used and the actual number of moles of product formed by the reaction before applying a formula such as 'percentage yield = (moles of product formed ÷ moles of reactant used) $\times$100'.
Question 6(a)(i)	A very high proportion of candidates could name the carboxyl group correctly.
Question 6(c)	This was another question assessing the candidate's ability to apply good numeracy skills in a chemical. Responses to this question indicated that most pupils were well prepared, laying out their working very clearly. This question also included a mark for the correct use of units which, again, a large number of candidates were able to secure.
Question 6(d)(i) & (iii)	Candidates had a good grasp of chromatography, being able to correctly rationalise retention times in terms of structure, and to show an appreciation of factors determining the possible use of chromatograms for quantitative work.
Question 9	This problem solving question was answered well.
Question 10(b)(i)	Candidates had a very good grasp of titration technique proving very familiar with the use of a rough titre at the start of a titration.
Question 11(c)(ii)	Candidates were well aware that catalysts do not alter the position of equilibria.
Question 13(a) & (b)(ii)	Each year there is at least one problem-solving question that requires candidates to decode unfamiliar information. In previous years candidates in the traditional paper have often been reluctant to attempt these questions, perhaps losing confidence at seeing chemistry they have not encountered during their exam preparation. These questions were attempted by almost every candidate with many securing both marks available.

Areas which candidates found demanding

The following Questions in Section A produced low facility values.

Question 4	Just under a half of candidates failed to appreciate that polar covalent bonding cannot be found in elements as, in an element, all atoms are identical and have the same electronegativity.
Question 24	Only around half of the candidates could predict relative atom economy and percentage yields when only given a balanced equation and information on the position of equilibrium.
Question 29	Just under a half of the cohort had difficulty selecting the piece of apparatus capable of measuring a given volume of solution to the greatest degree of accuracy from a list provided.

In Section B, candidates experienced difficulty in the following questions.

Question 2(b)	Few candidates were able to balance the ion-electron equation correctly by adding appropriate numbers of hydrogen ions and electrons.
Question 4(b)(i)	The marking instructions for this question were looking to see the candidate clearly indicate the role of emulsifiers in forming suspensions formed from polar and non-polar components. Many candidates gave answers of the form, 'to stop the chocolate from separating' which were not awarded a mark as they did not clearly indicate the presence of polar and non-polar substances.
Question 6(a)(iii)	Candidate answers showed an incomplete understanding of the nature of the salt formed when a carboxylic acid reacts with an alkali such as sodium hydroxide solution. Structures showing a covalent bond between sodium and oxygen atoms, or structure showing incorrect charges on the sodium and carboxylate ions were not awarded marks.
Question 10(b)(iii)	While the majority of candidates correctly calculated the mass of sodium thiosulfate required to make the desired standard solution. Many candidates did not then go on to describe the experimental procedure required to ensure that this mass of solute is transferred quantitatively to an appropriate standard flask and the solution then made up accurately to the desired volume.
Question 11(a)(ii)	This question assessed candidate's knowledge of the data handling techniques specified within the Research Chemistry Unit. (Please see arrangements documents for *Chemistry (Revised) Higher, Valid from August 2011, First edition - published December 2010* page 82) Candidates should appreciate that, where appropriate, a line of best-fit should be drawn through data points and, where a single data point clearly lies well from the overall pattern, this may be regarded as a rogue point. A large number of candidates made no attempt to construct lines of best fit and took their value from the single point which did not fit the clear pattern shown by the other data. Another example of this type of question is given in the Specimen Question paper, Section B question 9(b).

Advice to centres for preparation of future candidates

General

As mentioned earlier, the Revised Higher Chemistry course presents different challenges from the traditional course and centres might find the following advice helpful regarding aspects of assessment that are new for the Revised Higher course.

Open-ended questions

To allow candidates the opportunity to demonstrate their understanding of underpinning chemical concepts and their ability to apply these ideas creatively in unfamiliar contexts, the examination for the Revised Higher course contains open-ended questions. These questions are signposted for candidates by use of the phrase, 'using your knowledge of chemistry' printed in bold text within the question stem.

The nature of these questions is such that there is not a single definitive correct answer.

There are three marks allocated to each open ended question. Markers will allocate a mark based on the level of understanding illustrated by the candidate's answer.

1 mark: The candidate has demonstrated a limited understanding of the chemistry involved. The candidate has made some statement(s) which is/are relevant to the situation, showing that at least a little of the chemistry within the problem is understood.

2 marks: The candidate has demonstrated a reasonable understanding of the chemistry involved. The candidate makes some statement(s) which is/are relevant to the situation, showing that the problem is understood.

3 marks: The maximum available mark would be awarded to a candidate who has demonstrated a good understanding of the chemistry involved. The candidate shows a good comprehension of the chemistry of the situation and has provided a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the problem. This does not mean the answer has to be what might be termed an 'excellent' answer or a 'complete' one.

As a general principle it is worth emphasising that, whilst a candidate could score 3 marks by writing an extended paragraph covering a large number of different relevant facts and ideas, it would also be possible for a candidate to score 3 marks with a single sentence if that sentence proved to demonstrate a remarkably perceptive and profound solution to the question.

The 2013 paper contained two open-ended questions.

In question 4(d) candidates were asked to use their knowledge of chemistry to show that both ionic and covalent compounds are present in chocolate. In answering this question candidates demonstrated a wide knowledge of chemical facts and applied their underlying knowledge of bonding and properties in creative and impressive ways.

Candidate answers tended to adopt one or more of the following possible themes:

Ionic compounds will demonstrate electrical conductivity in solution or when molten. As well as straightforward tests of electrical conductivity, candidate answers often mentioned the use of electrolysis experiments and some cases detailed the type of power supply to use (dc), appropriate types of electrodes and suggested probable experimental observations for the experiments.

Ionic compounds also tend to have higher melting and boiling points, and may demonstrate differences in solubility when compared to typical covalent substances. Candidate answers pursuing this line of thought often mentioned;

- the absence of covalent network substances evident from the relatively low melting point and softness of chocolate
- the presence of covalent molecular substances evident from the relatively low melting point of chocolate
- possible experiments to attempt to separate ionic and non-polar covalent substances by exploiting differing solubilities in water
- experiments designed along the lines of fractional crystallisation in which the differing melting points and solubilities of substances would be used to separate covalent from ionic compounds
- experiments describing forms of distillation in which covalent compounds would be removed as gases leaving the ionic compounds behind as residue

Knowledge of the chemical nature of compounds mentioned in a list of the ingredients used to make chocolate, possibly referring to the list of ingredients which would appear on commercial chocolate packaging, can be used as a starting point to draw up lists of ionic and covalent compounds. Candidate answers pursuing this line of thought often mentioned:

- Sugars — these are carbohydrates and these are examples of polar covalent compounds. (Some candidates provided additional information on the structure of carbohydrates, or named specific sugars).
- Fats — these edible oils are covalent compounds. (Some candidates provided additional information on the structure of edible oils).
- Esters may be present as flavourings — these compounds are all covalent compounds. (Some candidates explained the link between fruit-type flavours and these compounds. Chocolate oranges tended to feature in these answers!)
- Aldehydes and ketones are present in flavour compounds — these are covalent compounds. (Candidates related this back to the phenylethanal and 1,3-diphenylpropan-2-one mentioned earlier in the question and/or terpenoids that might be present).
- Salt is present in chocolate — this is an ionic compound.

Many candidates adopted more than one of the possible approaches above, some demonstrating considerable sophistication in discussing the fact that polar covalent compounds can, in some instances, exhibit behaviours similar to ionic compounds.

In question 12 candidates were asked to comment on the accuracy of a statement asserting that cooking could alter compounds from being fat-soluble to being water-soluble. Again, candidates demonstrated a wide knowledge of chemical facts and applied their underlying knowledge of organic chemistry in a number of ways.

Candidate answers tended to adopt one or more of the following possible themes.

> 'Like dissolves like' so compounds in food which are polar or are capable for forming hydrogen bonds are likely to be water soluble whilst non-polar molecules are likely to be fat soluble.

> Foods contain edible fats and oils. These substances can undergo hydrolysis during cooking. Candidates discussing these compounds often mentioned:

- edible oils are non-polar and so are not water soluble
- structure of fats and oils
- the ester link present in edible oils can undergo hydrolysis
- structure of glycerol leads to hydrogen bonding
- fatty acids have a polar carboxyl group but can also have long less hydrophilic hydrocarbon tails
- fatty acids formed by hydrolysis may undergo further reactions e.g. neutralisation with basic compounds in food
- partial hydrolysis of fats may lead to the formation of emulsifiers which may create suspensions of fat-soluble compounds in water
- transesterification may occur if other compounds containing hydroxyl groups are present in food

> Proteins in foods may undergo hydrolysis reactions when they are heated in the presence of water. Candidates discussing these compounds often mentioned:

- amide or peptide link
- formation of amino acids during hydrolysis
- the possible catalysis of hydrolysis reaction by acids or alkalis present in the food

> Proteins in foods may be denatured by gentle heating. Candidates discussing these reactions often mentioned:

- role of hydrogen bonding in maintain shape of proteins
- changes in shape of proteins during heating
- relative solubility of globular proteins compared with fibrous
- changes to egg white during cooking

Food can be cooked by boiling, steaming or frying. Candidates discussing cooking methods often mentioned:

- how flavour molecules may be fat or water soluble
- how flavour molecules may be lost from foods
- how certain vitamins are fat-soluble

Cooking can result in the oxidation of compounds which may result in changes to their polarity. Candidates discussing oxidation often mentions:

- alcohols contain hydroxyl groups and so are water soluble
- oxidation of primary alcohols produces aldehydes which do not contain O-H bonds and so are not as polar and are likely to be less soluble in water
- oxidation of secondary alcohols produces ketones which do not contain O-H bonds and so are not as polar and are less likely to be soluble in water
- oxidation of aldehydes produces carboxylic acids which contain carboxyl groups and so may be more polar than the parent aldehyde

Although cooking can cause chemical reactions converting one substance into a new substance, whether a particular compound is itself fat or water soluble would not change.

Most centres had clearly taken time to prepare their candidates to be able to answer these questions and markers reported that it was clear that many centres had provided their candidates with a common strategy to help candidates to formulate and structure their ideas. Some centres had clearly adopted a 'bullet point list' approach, whist others seemed to be following a strategy of noting relevant key points at the beginning of the answer then going on to formulate a few sentences addressing the specific question. A vital point for all teachers and lecturers is to ensure that all of their candidates have the expectation of picking up at least some marks in these questions even if they can only display a limited knowledge of relevant chemistry in their answer.

It was reassuring to see that candidates limited their answers to the space provided and, in almost all cases, provided answers no longer than would be appropriate for the 3 marks allocated. Further advice for centres and candidates is available from the Education Scotland website.
(http://www.educationscotland.gov.uk/resources/nq/c/nqresource_tcm4628999.asp)

Assessment of Skills developed within the Researching Chemistry Unit

Skills developed in the Researching Chemistry unit of the course assessed throughout the exam. During the course learners should be given every opportunity to engage in investigative and illustrative practical work. The arrangements document specifies the apparatus in addition to the practical and data analysis techniques with which Higher candidates should be familiar. The following list provides examples of questions in the 2013 paper which assess these skills.

Practical Techniques	**Section A Question**	**Section B Question**
Filtration	30	
Titration (including use of volumetric flask)		10(b)(i), 10(b)(iii)
Methods for the collection of a gas: over water, using a gas syringe		7(a)(i)

Data Analysis Techniques	**Section A Question**	**Section B Question**
Sketching lines or curves of best fit		11(a)(ii)
Identification and elimination of 'rogue points' from the analysis of results.		11(a)(ii)
Qualitative appreciation of the relative accuracy of apparatus used to measure the volume of liquids.	29	

Candidates are also required to demonstrate that they can design an experiment or evaluate the effectiveness of a given experimental procedure and suggest improvements. Example of these skills being assessed are provided in Section B by questions 6(d)(ii), 7(a)(i) and 10(b)(i).

Calculations

Numeracy is a key skill developed by the Higher Chemistry course and calculation type questions accounted for 28 marks in the 2013 paper. Within the exam candidates are required to undertake two types of chemical calculation.

Firstly, candidates are required to carry out a number of standard chemical calculations directly related to content statements within the unit descriptions. Problems of this type can usually be solved by applying well practiced routines. Examples of these would include; Hess's law calculations (section B questions 8(a), titration calculations (section B question 10(b)(ii)), percentage yield calculations (section B question 5(b)).

Secondly, candidates are required to demonstrate their general scientific numeracy skills by solving problems of an unfamiliar type within unfamiliar chemical contexts. Whilst it is unlikely that a candidate will ever have carried out the specific type of calculation in the exam, a good understanding of proportion will in most cases suffice. Examples of these would include; calculating the mass of theobromine present in a biscuit (section B, question

4(c)), calculation of the maximum safe dose of lidocaine for an adult (section B, question 6(c), calculation of cost of cask strength malt required to produce a bottle of whisky for retail (section B, question 11(b)(ii).

In all calculations worth more than 1 mark, candidates should be aware that credit will be given for the correct demonstration of chemical concepts or for intermediate results in a multiple step calculation. They should be encouraged to show their working clearly in order to maximise their chances of obtaining partial marks.

Statistical information: update on Courses

Number of resulted entries in 2012	266

Number of resulted entries in 2013	652

Statistical information: Performance of candidates

Distribution of Course awards including grade boundaries

Distribution of Course awards	%	Cum. %	Number of candidates	Lowest mark
Maximum Mark 100				
A	47.2%	47.2%	308	72
B	22.2%	69.5%	145	60
C	17.2%	86.7%	112	49
D	5.5%	92.2%	36	43
No award	7.8%	100.0%	51	-

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.