External Assessment Report 2012

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 distribution of marks across the different types of questions is detailed in the Course Arrangements document for Revised Higher Chemistry. For benchmarking purposes, Section A of this paper shared 17 questions in common with the traditional Higher, whilst Section B of the revised paper shared 16 marks in common with the traditional paper.

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 underlying chemistry and, consequently, there is a greater total number of marks assigned to questions requiring extended answers. The revised Course places significant emphasis on the development of numeracy skills and, in addition to the type of well-rehearsed calculation types found in the traditional examination, the revised paper contains a number of questions which assess numeracy skills in unfamiliar chemical contexts. In considering the marking of candidate papers it should be remembered that, unlike in the examination for the traditional Course, half-marks are not used.

The overall impression of the paper from feedback received was that it that the revised Chemistry paper was fair but challenging.

In general, candidates appeared well prepared for the examination with knowledge of the new content introduced in this Course. Feedback from Markers confirmed that the time allocated to the examination was appropriate to all candidates to answer all questions.

Centres appeared to have taken considerable care preparing candidates for the different types of questions to be found in the new examination and candidates clearly understood what was being asked and demonstrated good examination technique. Questions relating to experimental work were well answered suggesting that most candidates had considerable experience of practical investigative work.

Areas in which candidates performed well

The following Questions in Section A produced high facility values.

Question 1: Electronegativity

Question 3: Bonding and structure

Question 6: Intermolecular forces

Question 12: Naturally occurring compounds formed from carboxylic acids

Question 14: Amide links

Question 17: Functional groups in alcohols, aldehydes and carboxylic acids

Question 18: Oxidation of alcohols

Question 22: Catalysis

Question 24: Enthalpy change from a reaction profile

Question 25: Rates of reaction — effect of temperature increase

Question 30: Reproducibility

In Section B, candidate performance merits special mention in a number of questions.

Question 1 (a) parts (i) and (ii) well answered very well, but perhaps more impressive still was the answers provided by students in part (b) where an explanation of a periodic trend in electronegativity was required.

Question 2 (b) was well answered, with candidates able to apply direct proportion principles to calculate the mass of peanuts required to supply the recommended daily allowance of zinc.

Question 4 (b) (i) and (ii) were answered well with candidates showing a good knowledge of the carbonyl functional group and the products of the oxidation of aldehydes.

Question 5 (b): Most candidates had no difficulty in combining oxidation and reduction ion–electron equations.

Question 6(a) was well done, with the vast majority of candidates able to draw a full structural formula for dimethylsulphide.

Questions 7 (b) and (c) were both very well answered with candidates able to extract information on bonding from an unfamiliar type of graph.

Question 8 (a) was particularly well answered with candidates able to write the structure of a particular isomer by deducing the relationships present between structure and the boiling point and flash point values for a series of organic compounds.

Question 9 (b) (ii) presented candidates with a chromatogram for a drink sample in which the detector response had saturated on the peak for caffeine. The candidates were asked to describe what could be done to allow the caffeine level to be measured. The majority of candidates were able to write clear, practical methods of addressing this problem.

Question 10 (b) (i) indicated that candidates were able to name esters accurately.

Although atom economy is a calculation type not found in the traditional Higher Chemistry Course, Question 10 (b) (ii) showed that the majority of candidates had been well prepared to tackle this type of question.

Question 10 (c): The percentage yield calculation was done well. 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’. However, a number of candidates are successfully answering 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 11 (b) (ii): Hess’s law calculations are generally well done.

Question 12 was particularly well done, with candidates showing good knowledge of various methods of gas collection and of the suitability of different methods of heating.

Areas which candidates found demanding

The following questions in Section A produced very low facility values.

Question 9: Balancing an ion–electron equation

Question 26: Concept of excess — Calculation of the enthalpy change for a reaction in which one reactant is in excess.

Question 29: Chromatography

In Section B a number of questions proved particularly challenging.

Question 4(a): In this question a number of candidates failed to establish that geraniol will have hydrogen bonding between molecules and attempted to explain the difference in the ease of evaporation in terms of London dispersion forces.

Question 6 (c) (ii): Only a minority of candidates appreciated that a standard solution was one of accurately known concentration. Many gave answers such as ‘a solution from a standard flask’.

Question 9 (b) asked candidates to draw the structural formula for a compound produced when a particular molecule is hydrolysed.

Question 13 (a) tested whether candidates appreciate that the electrochemical series provides an indication of the relative strengths of oxidising agents. Candidates were asked why fluorine cannot be produced by oxidising a fluoride salt using acidified permanganate. Most neither appreciated that fluorine is a stronger oxidising agent than permanganate nor made any reference to their relative positions in the electrochemical series.

Question 13 (b) (ii) proved difficult for many candidates. Many struggled to suggest a termination reaction for this example.

Perhaps because the product shown was an example of a soap, in Question 14 (b) (i) the majority of candidates stated that the reaction between stearic acid and sodium hydroxide would be an example of saponification rather than the correct answer — neutralisation.

Advice to centres for preparation of future candidates

General

As mentioned earlier, the assessment for the Revised Higher Chemistry Course differs from the traditional Course in a number of ways. Centres might find the following advice on some of the new aspects of assessment helpful.

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.

The 2012 paper contained two open-ended questions.

In Question 4 (c) candidates were asked to use their knowledge of chemistry to comment on the possible smell(s) were a 3,500 year old bottle of Egyptian perfume to be opened. In answering this question candidates demonstrated a wide knowledge of chemical facts and were able to apply their knowledge of chemical structure and. Student answers generally covered one or more of the following themes:

- The smells associated with the original ingredients: terpenes and their derivatives (floral or spicy), esters (fruity), ethanol (penetrating solvent type smell).
- The possible products of oxidation of the ingredients: terpenes to terpenoids (changing floral smells to heavier, more spice-like aromas), edible oils (production of rancid smells), ethanol to ethanol and ethanoic acid (formation of vinegar-like smell).

- The possible hydrolysis of the ingredients: edible oils (production of glycerol and foul-smelling fatty acids), esters (loss of fruity smells and the production of less pleasant smelling long chain alcohols and carboxylic acids)
- Changes occurring across time as a result of the differing volatilities of the ingredients: components such as the edible oil have high boiling points so would only be lost slowly by evaporation whilst any fruity esters and terpenes with low boiling points might quickly be lost.
- The possible influence on the rates of various reactions of the local climate within the Egyptian tomb: effect of temperature and humidity on rates of hydrolysis and oxidation.
- The design of the bottle: airtight seal (preventing loss by evaporation and oxidation by atmospheric oxidation), opacity to ultraviolet light (preventing the formation of free radicals hence reducing the rate of oxidation)
- Chemical reactions between the ingredients: hydrolysis of the edible oils and esters by the water component, cross-esterification of the various esters with the ethanol solvent and each other.

Some candidates demonstrated a depth of understanding of relevant chemistry going well beyond what might have been anticipated at this level. For example, several candidates explained clearly how the presence of carbon to carbon double bonds in terpenes or in edible oils renders them susceptible to oxidation.

In Question 15 candidates were presented with drawing showing a section of a hydrogel and were asked to use their knowledge of chemistry to comment on how suitable this material would be for absorbing spills in the lab. Student answers generally covered one or more of the following themes:

- The hydrogel is a very large molecule with a large number of carboxyl groups: the hydrogel will have very high melting and boiling points and so will not evaporate easily, it will be a solid a room temperatures, it will have very strong van der Waals' forces.
- The hydrogel will absorb polar molecules due to the presence of polar groups on the polymer chain. Candidates gave many examples of polar compounds commonly found in laboratories often providing an explanation of why these compounds would be likely to be found in a lab. For example, they would explain how alcohols would be used in the lab as solvents or in disinfectant.
- The carboxyl group on the hydrogel could react with several classes of laboratory reagent: with alcohols to form esters, with bases to form salts, with amines to form amides.
- The potential flammability of the hydrogel: combustion products (carbon dioxide and water), low potential flammability due to low volatility (relating these to the very large size of the molecule and the presence of strong hydrogen bonding), ability to prevent the evaporation of other flammable substances (alcohols used a solvents would be absorbed due to their polarity).
- The ability of the carboxyl groups to for carboxylate ions.

Several candidates presented well considered evaluations of the overall polarity of hydrogel molecules based on the possible three-dimensional structure of this molecule. Such candidates described an outer sheath of highly polar carboxylate groups encasing the non-polar carbon backbone.

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 are assessed throughout the exam. Learners should be given every opportunity to engage in investigative and illustrative practical work. The Arrangements document specifies the apparatus, practical techniques and data analysis methods with which Higher candidates should be familiar. The following list provides examples of questions from the 2012 paper which assess these skills.

Practical techniques	**Section B question**
Titration	6 (c) (i)
Methods for the collection of a gas: over water, using a gas syringe	12 (a)
Safe methods for heating: Bunsen burners, water baths or heating mantles	12 (b) (i)

Data analysis techniques	**Section A question**	**Section B question**
Calculation of averages (means) for experiments		2(a)
Identification and elimination of 'rogue' points from the analysis of results		2(a)
Qualitative appreciation of the relative accuracy of apparatus used to measure the volume of liquids		6(c)(i)
When a measurement has been repeated, candidates should appreciate that any variations in the value obtained give an indication of the reproducibility of the technique	30	

Candidates are also required to demonstrate that they can evaluate the effectiveness of an experimental procedure and suggest improvements. These skills are assessed in Section B by questions such as 3 (a) (ii) and 9 (b) (ii).

Calculations

Numeracy is a key skill developed by the Higher Chemistry Course and calculation type questions accounted for 26 marks in the 2012 paper.

Candidates are required to perform two types of chemical calculation.

Firstly, candidates are required to carry out a number of standard chemical calculation types specified by content statements within the Unit specifications. Problems of this type can be solved by applying well-practised routines. Examples would include; Hess's law calculations

(Section B Question 11 (b) (ii)), titration calculations (Section B Question 6 (c) (iii)) and percentage yield calculations (Section B Question 10 (c)).

Secondly, candidates are required to demonstrate their numeracy skills by solving problems within unfamiliar chemical contexts. Whilst it is unlikely that a candidate will ever have carried out the specific types of calculation in the exam, a good understanding of proportion will, in most cases, suffice. Examples of this type of question would include calculating the mass of a foodstuff equivalent to the RDA (Section B, Question 2 (b)), calculation of the chemical energy stored in a given volume of fuel (Section B, Question 3 (b)) and calculation of the caffeine content of a drink from a chromatogram (Section B, Question 9 (b) (i)).

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 2011	-

Number of resulted entries in 2012	266

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	34.6%	34.6%	92	73
B	28.9%	63.5%	77	61
C	17.7%	81.2%	47	50
D	7.1%	88.3%	19	44
No award	11.7%	100.0%	31	-

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.