



## External Assessment Report 2012

Subject (s)	<b>Chemistry</b>
Level (s)	<b>Higher</b>

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 2012 paper followed the pattern of question types seen in recent years, and assessed candidates' knowledge across all Units and performance criteria.

The overall impression of the paper from feedback received was that it was fair but challenging. In general, candidates performed well demonstrating a good level of understanding and attainment across the paper. Most candidates appeared well practised in answering the different types of question found in Higher Chemistry and very few candidates failed to attempt every question.

Candidates had been particularly well prepared for all of the standard calculation types: mole calculations, Hess's law calculations, Faraday calculations, etc. As in previous years, questions requiring the candidate to write detailed explanations remain an area in which many struggle.

## Areas in which candidates performed well

The following questions in Section A produced high facility values.

Question 1: Standard Grade/ Intermediate 2 — definition of an isotope

Question 6: Rates of reaction — effect of temperature increase

Question 8: Enthalpy change from a reaction profile

Question 11: Bonding and intermolecular forces

Question 15: Use of the Avogadro number

Question 16: Molar volumes

Question 18: Octane numbers

Question 19: Alternative fuels — biogas

Question 22: Functional groups in alkanols, alkanals and alkanolic acids

Question 24: Aromaticity

Question 25: Addition reactions

Question 26: Oxidation of alcohols

Question 27: Synthesis gas

Question 32: Catalysis

Question 38: Faraday's law

Question 39: Nuclear fusion

In Section B, the majority of candidates demonstrated well-rehearsed strategies when attempting standard calculation types. They performed particularly strongly in the following questions.

Question 2 (b) (ii): Candidates had no difficulty calculating an average rate from a reaction progress graph.

Question 4 (c): A very high proportion of candidates could calculate the fraction of a radioisotope remaining after a given time.

Question 10 (c): The percentage yield calculation was particularly well done. 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  $\div$  theoretical yield)  $\times$  100'. However, an increasing 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  $\div$  moles of reactant used)  $\times$  100'.

Question 11 (b) (ii): Hess's law calculations are generally well done.

Question 13 (a): Most candidates scored highly in this Faraday's law question.

This year, candidates appeared particularly willing to attempt problem-solving questions and answered well in Questions 6 (a), 9 (b), 11 (a) (ii), 13 (b) (ii), 16 (a) and 16 (b).

Other areas of the Course in which candidate performance was strong are highlighted by the following questions.

Question 1 (a) and 1 (b): Candidates were able to identify a covalent network and understood the cause of the trend in covalent radius observed moving across a period.

Question 4 (b) (i): The majority of candidates were aware that the half-life for a nuclear decay process is not affected by temperature change.

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

Question 5 (c): Almost all candidates could state a definition for the term heterogeneous catalyst.

Question 7 (b): Most candidates were able to write an accurate molecular formula from a structural formula for an aromatic compound.

Question 7 (c): Most candidates were able to accurately indicate hydrogen bonding between peptide chains.

Question 9 (c): A high proportion of candidates could correctly identify a hydrophilic group within a soap.

## **Areas which candidates found demanding**

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

Question 3: Standard Grade/Intermediate 2 — electron arrangement for an ion

Question 9: Concept of excess — calculation of the enthalpy change for a reaction in which one reactant is in excess

Question 37: Balancing an ion–electron equation

In Section B, questions relating to experimental work were often not well answered, which could be indicative of a lack of exposure to practical work.

In Question 2 (a), candidates were presented with a description of an experiment in which the progress of a reaction is followed by measuring the change of mass occasioned by the loss of carbon dioxide from a flask. Although not a prescribed practical activity, this type of experiment is featured in course textbooks and commercial revision guides — and has featured in previous examinations. Candidates were asked to suggest why a cotton wool plug had been placed in the mouth of the conical flask shown. Disappointingly, the most common candidate answer was that the cotton wool plug had been placed in the flask to prevent carbon dioxide escaping — an answer that both showed not only a lack of understanding of this type of mass loss experiment, but also a lack of knowledge of the purpose of the cotton wool plug used in the prescribed practical activity ‘Making an Ester’. Knowledge of this prescribed practical was by tested by Question 8 (d) which over one-third of candidates were unable to answer.

Question 12 assessed the prescribed practical activity, ‘Factors Affecting Enzyme Activity’. As in previous years, there are some centres in which relatively strong candidates are underperforming in the prescribed practical activity (PPA) questions, which could possibly be the result of a lack of active participation in these experimental activities. Less than one-third of candidates managed to explain why the potato discs must be left in the mixture and even fewer knew that hydrogen peroxide is used in this experiment.

Other questions within Section B that presented difficulties for candidates are indicated below.

Question 2 (b) (ii) proved to be exceptionally challenging for candidates, very few of whom were able to relate the mass changes observed to the mass of copper present in the original sample.

Question 4 (b) (ii) required candidates to calculate the mass of strontium-89 present in 10 g of strontium-89 chloride. This type of question has appeared in previous years and always proves highly discriminating. The most common error is for candidates to calculate the number of moles of  $\text{SrCl}_2$  using the relative atomic mass of strontium in place of the atomic mass of 89.

Question 8 (b) asked candidates to draw the structural formula for a compound produced when a particular molecule is hydrolysed.

In Question 11 (a) (i), under half of the candidates could name a branched chain alcohol from its structural formula.

Whilst in Question 14 (a) (ii), many candidates were able to state that ammonium nitrate is the salt of a strong acid and weak base, fewer were able to write the equilibria involved or explain why the solution of such a salt is alkaline.

## **Advice to centres for preparation of future candidates**

### **General**

Much of the following advice, based on the responses to the questions in Section B of the paper, has been given for a number of years. However, some centres, particularly those in which the number of awards at the different grades is less than the number that is estimated, may still benefit from a consideration of this information.

Every Higher paper will contain a number of questions that assess candidate recall of material from underlying Courses, that is, from the topics common to both the Standard Grade and Intermediate 2 Courses. Examples of this type of question can usually be found early in Section A, eg Questions 1, 2, 3 and 4, but these questions may also be embedded within Section B, eg Question 11 (b) (i). Recall of some parts of the Standard Grade/Intermediate 2 content can be particularly poor and candidates may benefit from some revision of the key aspects of carbohydrate chemistry, the reactions of metals, corrosion and precipitate formation.

### **Information on specific types of questions**

Within Section B there are a range of different types of questions designed to test different skills; some require simple recall, some require candidates to provide an explanation, some require the application of problem solving or data-handling skills. Each Higher paper will contain at least one question of each type, so it is to the candidate's advantage to be able to recognise each of these forms of question within the paper and to know what type of answer is required. Some of the key question types are described below.

#### *Calculations*

Some centres proved to be particularly effective at preparing their candidates for calculation questions, with even their weaker students managing to secure a significant number of marks in these questions. It was noticeable that, for these centres, almost all of their candidates would use the same basic layout for their calculations suggesting that their candidates are well practised at applying a single, taught strategy to tackle proportion-based questions. As these candidates tended to show all of the individual steps within a calculation, even the weaker candidates were able to pick up partial marks in most questions.

Candidates should continue to make every effort to learn basic 'routines' for the different types of calculations in the Course. Due to partial marking, a significant number of part-marks can be picked up. Candidates should also be aware that there is also the opportunity for 'follow through' without further loss of marks once a mistake has been made.

#### *Prescribed practical activities*

Every Higher paper will assess candidate knowledge obtained through the experience of the prescribed practical activities. In each paper, knowledge of at least three of the PPA experiments will usually be assessed. This may be by questions which clearly signpost the experiment concerned, such as Question 12, or by questions in which the candidate's knowledge of a particular reaction or technique is embedded within a different context, for example Question 8 (d).

### *Problem solving within the context of experimental design*

Each year there is at least one problem-solving question that requires candidates to think about an unfamiliar experiment, for example Question 2 (a).

### *Problem solving involving unfamiliar contexts*

Each year there is at least one problem-solving question that requires candidates to decode unfamiliar information (Question 16). Here again, centres may wish to review how the skills assessed in this type of question are developed over the Course.

### *Questions requiring a detailed explanation*

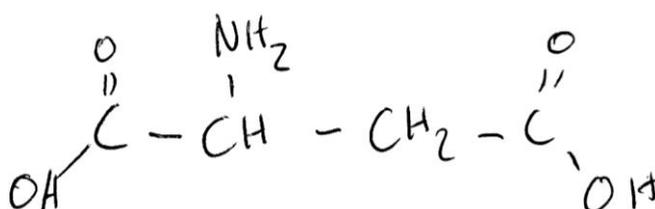
Each year there is at least one question that requires more detailed explanations from candidates (Questions 6 (b) (ii) and 14 (b) (ii)). These questions are signposted for candidates, by the word 'explain' appearing in bold print within the stem. Centres should reconsider the extent to which candidates are given opportunities to practise answering such questions. These questions will also tend to carry a mark allocation of at least two marks in recognition of the more detailed response required.

## **Questions involving the formulae of organic compounds**

Candidates will be required to answer questions involving molecular formulae (Question 7 (a)), shortened structural formulae (Questions 8 and 9) and full structural formulae (Question 6 (a)). Common reasons for candidates to lose marks are:

- ◆ failure to show all bonds when a full structural formula is specifically requested
- ◆ when bonds are not shown connecting clearly to the correct atom in a shortened structural formula

For example, in the diagram below, the hydroxyl group on the left is attached via the hydrogen atom.



## **Areas of common misunderstanding**

Question 6 (b) (i): In this titration calculation, candidates were asked to calculate the concentration of hydrogen sulphide present in a sample of water given the volume and concentration of a chlorine solution used in a redox titration. Candidates needed to recognise the 4:1 relationship which exists between the number of moles of  $\text{Cl}_2$  and  $\text{H}_2\text{S}$  as shown in the balanced equation provided. Because the question was asking about a water

sample, a significant number of candidates used instead the 4:4 relationship of  $\text{Cl}_2$  to  $\text{H}_2\text{O}$  shown in the redox equation.

An astonishing number of those candidates who correctly managed to calculate the concentration of the hydrogen sulphide incurred a half mark penalty by writing the unit of concentration as  $\text{mol}^1$ . The correct unit of  $\text{mol l}^{-1}$  was given in the stem of the question.

Question 6 (b) (ii) revealed common misconceptions regarding the factors determining whether a molecule is polar or non-polar. Hydrogen sulphide is a polar molecule with a dipole moment of 0.98 debye and, as such, experiences permanent dipole-permanent dipole interactions. Evidence for the presence of these permanent dipole-permanent dipole interactions is provided if the boiling point of  $\text{H}_2\text{S}$  is compared with a molecule of similar size. For example:

- ◆  $\text{H}_2\text{S}$  has a relative formula mass of 34 and has 18 electrons
- ◆  $\text{F}_2$  has a relative formula mass of 38 and has 18 electrons

Higher candidates would expect the van der Waals' forces to be similar for these two molecules but whilst the boiling point for  $\text{F}_2$  (non-polar) is only  $-188\text{ }^\circ\text{C}$ , the boiling point for  $\text{H}_2\text{S}$  (polar) is almost  $130\text{ }^\circ\text{C}$  higher.

As there is a difference in electronegativity of 0.3 Pauling units between hydrogen and sulphur, a hydrogen sulphide molecule contains two polar covalent bonds. The question paper shows the correct shape for  $\text{H}_2\text{S}$ . Because hydrogen sulphide has a similar angular shape to water, the two S–H bond dipoles combine to generate a significant overall dipole for the molecule (0.98 debye). This is greater than the dipole of an FCl molecule (difference in electronegativity of 1.0) which is only 0.89 debye.

In their answers, some candidates argued that hydrogen sulphide would be non-polar because the difference in electronegativity between hydrogen and sulphur is the same as the difference in electronegativity between hydrogen and carbon. This highlighted a misconception regarding the non-polar nature of alkanes. Like hydrogen sulphide, alkanes have polar covalent bonds but, unlike hydrogen sulphide, the shape of these molecules results in the individual C–H bond dipoles cancelling each other out rather than combining. In the case of alkanes, a sheath of positively charged hydrogen atoms surrounds a negatively charged carbon backbone and, as there is not a 'positive side' and 'negative side' of the molecule, there is no overall dipole.

In the cases where candidates incorrectly stated that hydrogen sulphide was non-polar only a half mark was deducted. Candidates who gave a clear explanation of van der Waals' forces in these cases could still score  $1\frac{1}{2}$  marks in this question.

## Statistical information: update on Courses

Number of resulted entries in 2011	10,288
Number of resulted entries in 2012	10,361

## 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	31.4%	31.4%	3,257	75
B	25.2%	56.6%	2,611	62
C	22.4%	79.0%	2,316	49
D	9.3%	88.3%	965	42
No award	11.7%	100.0%	1,212	-

## **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.