Chemistry

2011 Assessment Report

Government
of South Australia

SACE
Board of SA

CHEMISTRY

2011 ASSESSMENT REPORT

OVERVIEW

Assessment reports give an overview of how students performed in their school and external assessments in relation to the learning requirements, assessment design criteria, and performance standards set out in the relevant subject outline. They provide information and advice regarding the assessment types, the application of the performance standards in school and external assessments, the quality of student performance, and any relevant statistical information.

SCHOOL ASSESSMENT

This was the first year in which all school assessment was moderated centrally.

Assessment Type 1: Investigations Folio

This assessment type consisted of practical investigations and issues investigations which were previously described as two assessment components, practical work and social relevance task(s) that have been centrally moderated for a number of years.

In both types of tasks, practical investigations and issues investigations, there were usually tasks which allowed students to demonstrate their abilities at the highest levels, as described in the performance standards with such terms as ‘critically’, ‘logically’, ‘systematically’, and ‘perceptively’. However, many tasks demonstrated extensive teacher scaffolding. Scaffolding is part of the teaching process, a means of providing appropriate support for students while they are learning. In the building industry, scaffolding is a temporary arrangement that supports the building process; when the building is complete the scaffolding is dismantled and the building stands alone. Similarly, in summative assessment tasks, scaffolding should be unnecessary — the learning should stand alone.[1] Scaffolding used in tasks included provision of tables for recording of data, directing students to discuss systematic errors, and provision of limited space for such discussion. Such prescription, while supporting students, limited their ability to present their own interpretation of data and other evidence, which sometimes contributed to evidence of a lower grade level than they might otherwise have been able to demonstrate.

When constructing tasks in this assessment type, the required skills and assessment design criteria should be distributed appropriately across the tasks. Calculations, data analysis, and error analysis are appropriate in volumetric and other quantitative tasks, whereas safety, the recording of qualitative observations, and analysis of procedures, while suited to all investigations, are particularly appropriate in the organic preparation. There were many instances where students attempted an analysis of systematic and random errors in their discussion of the organic preparation which is primarily a qualitative task.

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[1] This analogy is found in Sadler, D. R. (2007) ‘Perils in the meticulous specification of goals and assessment criteria’, *Assessment in Education: Principles, Policy & Practice*, 14:3, 387–392.

Practical Investigations

It was pleasing to note instances where students had learned the expectations for a discussion of practical investigations. The best responses demonstrated systematic and perceptive analysis and evaluation of data collected by relating their comments to the specific investigation. Less effective responses were of a generic nature which failed to address the specific nature of the investigation. Similarly, the better responses demonstrated an ability to 'critically and logically' evaluate procedures by suggesting improvements appropriate to the particular investigation, while weaker responses were, again, of a more generic nature. At times the work submitted reflected so much teacher influence (for example, similarity of responses for all students) that students were restricted in their ability to demonstrate their own interpretation of the data or experimental procedures. Some student work included verbose descriptions of procedures that had been provided to the students. Although some teachers may require students to do this, it does not address any requirements of the performance standards and may require an extensive time to complete.

Lack of opportunity and extensive scaffolding of tasks limited students' capacity to demonstrate evaluation of experimental procedures (specific feature AE2 in the subject outline) and analysis and evaluation of data (specific feature AE3) in much depth and therefore to achieve at the highest levels in these assessment design criteria. Some students who only used Excel to generate graphs demonstrated a limited ability to use the program effectively, with weaknesses in such processes as the assignment of variables to axes, selection of appropriate scales, and drawing lines of best fit. Consequently, these students were unable to demonstrate achievement at the higher levels in specific features such as the display of findings of investigations using appropriate conventions and formats (I4), the use of appropriate chemistry conventions (A2), and the communication of knowledge of chemistry in different formats (KU3).

A few of the samples failed to include an opportunity for students to design and perform an experiment to test a hypothesis, as specified in the subject outline. A small number of assessment groups had students designing an experiment to test a hypothesis but then undertaking a different experiment. This did not impact on the moderation of grade levels since the specific features being assessed could still be perceived in student responses.

It was pleasing to see the work of students who had been given the opportunity to design an investigation rather than make a simple modification to a given procedure. The latter practice limits students' opportunities to design 'logical, coherent, and detailed chemistry investigations', as described at the highest grades in the performance standards.

There was a poor understanding of systematic and random errors, with one common misunderstanding that an increase in the number of readings 'eliminates random errors'.

Issues Investigations

Some issues investigations tasks required students to present a discussion on a topic of social relevance rather than, as specified in the subject outline, requiring them to formulate a question, to identify and discuss alternative views, and to explain perspectives on the issue. In some instances students were provided with a list of questions and were required to *formulate* their own. This limited students' ability to demonstrate, at the highest levels, the specific feature AE1, 'Analysis and evaluation of connections between data, concepts, and issues in chemistry'. In several cases the topic chosen did not allow students to address some of the requirements of the subject outline. This applied to topics which had limited associated chemistry or which failed to provide the opportunity for alternative views. While it might be expected that the topic selected for an issues investigation provided opportunities to address KU2 (‘Use of knowledge of chemistry to understand and explain social or environmental issues’), this was not always the case.

Some student work exceeded the maximum of 1500 words specified in the subject outline. This word-count is inclusive of any evaluation of information gathered. The work beyond the word-limit was not considered in the moderation process. This sometimes affected the overall grade level, as a significant part of the analysis and evaluation assessment design criterion was addressed at the end of the work.

Students were generally able to correctly cite references in a list at the end of their report. However, few included in-text references when they had used a source, for example, for a diagram or graph. In some cases, the report presented consisted almost entirely of quotations with very little evidence of the student’s voice. While students are required to use and acknowledge sources of information, the majority of a report should be in their own words, with in-text quotations used sparingly.

While drafts are essential for teachers to be able to verify that the work submitted is the students’ own, such materials are not required at moderation.

Assessment Type 2: Skills and Applications Tasks

Students were generally given opportunities to display evidence in all the assessment design criteria to the highest standard. However, in this assessment type it appeared that some student work was awarded a grade level based solely on the overall percentage gained; there was no evidence that the tasks were designed using assessment design criteria or that student work was assessed using performance standards. This sometimes meant that students had few opportunities to relate concepts to social or environmental issues, or to solve problems and evaluate information in unfamiliar contexts. In some cases, material other than the content of the Chemistry subject outline was assessed. Tasks should be constructed on the basis of the key ideas and intended student learning described in the subject outline.

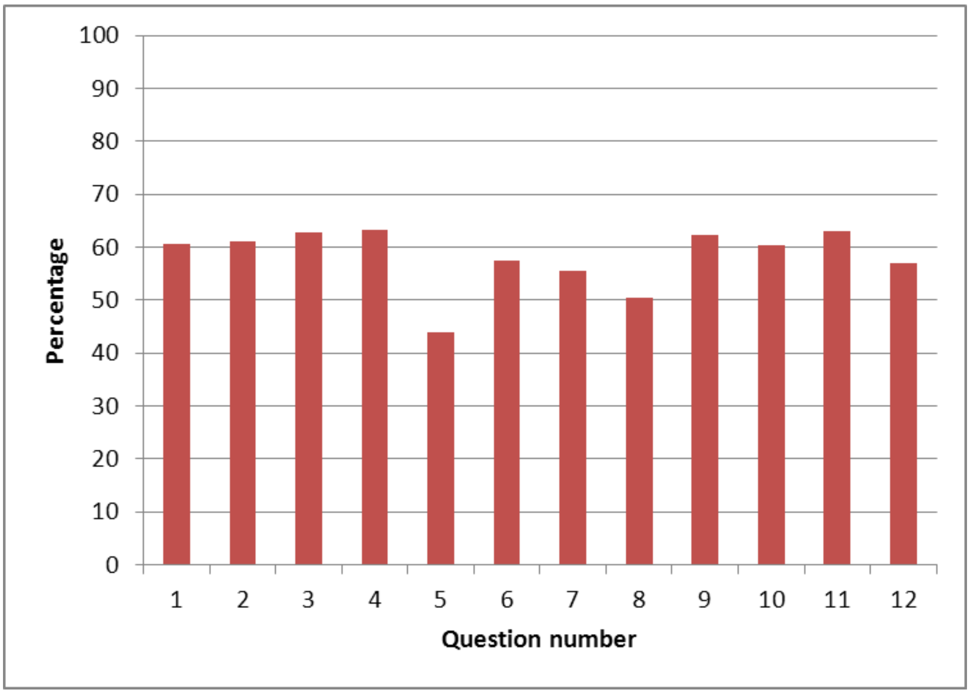
It was pleasing to note instances where teachers had developed excellent original tasks requiring students to apply their knowledge and understanding to new situations. In most cases, tasks were developed based on past examinations. While past examinations provide questions that cover the range of assessment design criteria, there is a need to select questions carefully, and there is always a risk that students will have previously seen the questions and the answers. In this case, students are not being required to use their learning to address unseen situations.

While moderation of student work was based on the extent to which students demonstrated achievement against the performance standards, it was disappointing to see instances where incorrect student answers had been marked as correct and, in some cases, correct answers had not been given credit.

EXTERNAL ASSESSMENT

Assessment Type 3: Examination

The mean percentage for the examination was approximately 58%. Differences between marks for questions showed a small range, with most showing a mean close to that of the examination as a whole. The graph below shows the mean percentage for each of the twelve questions.



The table below shows the mean for the examination, and the range of question means, for each of the last five years:

Year	Examination Mean (%)	Range of Question Means (%)
2011	58	44–63
2010	64	54–76
2009	58	36–69
2008	60	48–71
2007	62	49–72

General Observations

Students should be made aware that they are not to include additional sheets of paper in the script booklets. Information included on these sheets is not marked.

A disappointing number of students seemed to have not read questions or instructions carefully, sometimes with consequent effect on the mark achieved. One example was in drawing the structural formula of the *linear* tripolyphosphate ion when the question asked for the *cyclic* form (Question 4(b)(ii)(2)(A)). In other cases, formulae or structures given in the paper were read or copied incorrectly from the paper (for example, Question 1(e)(iii)) or parts of questions were omitted (for example, the repeating unit in the polymer in Question 1(d), and the direction of water flow in the diagram in Question 2(a)(iii)). *Read the question* and *answer the question*, cannot be emphasised too often. Students should be aware that additional marks are not awarded for repeating information provided in a question.

Correct use of chemical terminology (specific feature A2) was a weakness, and poor written expression (KU3) was common. While these problems were not penalised in themselves, any consequent ambiguity or inaccuracy was (for example, in Question 2(a)(vii), Question 3(b)(iii)(2), and Question 5(a)). Very few answers requiring either a statement or an explanation showed fluency, logic, clarity, and accuracy. Too many responses included key words used inappropriately, or, if used correctly, were followed by a contradictory statement. This was particularly evident in questions relating to bond and molecular polarity. Ambiguous and incorrect use of chemical terms will continue to be penalised.

Naming of organic compounds using IUPAC rules was poorly done. While this was most noticeable in inappropriate use of hyphens, capitals, and commas, the use of 'methy' and 'methane' instead of 'methyl' was also disappointingly common, as was failure to recognise the longest carbon chain in a compound.

A small number of students used the extra space at the back of the booklet, but did not draw any attention to it with a brief note at the point of the question.

There was little evidence that the paper was too long. There were very few instances where a student who had been scoring very well in early parts of Book 3 (Questions 9 to 12) left the last bits blank or wrote hurried, brief answers at the end.

Question 1

(a) (i) This question was rarely left blank. Most students wrote the equation correctly, although the equation for respiration and the use of equilibrium arrows appeared occasionally. However, some students wrongly added '+ energy' to the right-hand side of the equation.

(ii) (1) Most students were able to explain that coal is non-renewable because of its finite supply and/or its very long time to form, and that corn is described as renewable because it can be produced in a very short period of time. However, many responses were, at best, confused and, at worst, incorrect. Students tended to find it easier to say why corn is renewable rather than why coal is non-renewable. A common problem with many responses was that they focused on the *use* of the fuel rather than on the *supply*. It is accepted that coal formation requires periods measured in millions of years, yet some responses suggested formation requires as little as hundreds of years, while others specified that billions of years are needed. Some students clearly believe the terms 'renewable' and 'recyclable' to be interchangeable. Responses suggested that, after burning, coal could not be used again, whereas corn could, or that the products of coal combustion could not be reused, while the products of combustion of corn could. Another example of confusion was between renewability and the potential to contribute to pollution. Students suggested that the use of coal releases CO_2 which contributes to global warming, whereas CO_2 generated from corn does not; if this point is to be claimed, it needs to be explained.

(2) Many students ignored the fact that use of renewable resources for fibres would help prolong the lifetime of the remaining supplies of non-renewable resources for uses where there are currently no alternatives. Few students received full marks and a significant number received

none, while many answers merely rearranged information given in the question. Very few stated a benefit and then gave an explanation. A number of students did not relate their answers to the *production* of the fibre, referring, instead, to its *recycling*. Responses showed a great deal of overlap with the previous question. Many responses referred to the infinite supply of corn rather than the consequent potential for unlimited supply of the product fibre. A few responses focused on the capacity for corn to absorb CO_2 during growth and the possible benefit in terms of sustainability and global warming. Reduced damage to the environment through reduced mining was also noted by some.

(b) About 25% of students failed to gain a mark for this question by giving an answer that was too general, such as 'better for the environment' or 'environmentally friendly'. The most successful responses referred to the relatively short time required for decomposition of biodegradable polymers and hence reduced litter problem. Students commonly confused *biodegradable* with *thermoplastic* and discussed the benefits of reshaping and reusing the polymer.

(c) Many knew the subject outline definition of carbohydrates and answered well. However, it was surprising to find, after many past examinations with similar questions, how many students continue to believe that a structure that conforms to the general formula $C_x(H_2O)_y$ is a carbohydrate. It is estimated that at least 25% of the students responded in this way. Another common error, from students who knew that polyhydroxy ketones were carbohydrates, claimed that lactic acid satisfied this definition, not recognising the –COOH group present.

(d) Almost all responses were correct, although a significant number of students did not respond.

(e) (i) While most students identified the ester functional group, a disturbing number named it as a ketone, carboxyl or carboxylate group.

(ii) Another question where many students had trouble articulating a clear response. Common responses included the identification of two repeating units, the presence of an ester group, and claims that there are two chains. Some students who correctly identified that it was formed by condensation stated that there must be two monomers and failed to refer to the structural formula given. Some students who identified the different side chains (methyl and ethyl) on adjacent monomer residues referred to them as different functional groups.

(iii) Reasonably well done, although a significant number of structures omitted one of the functional groups (usually the alcohol) and a few repeating units were shown, while others drew a trivalent carbon attached to the hydroxyl group. Poorly drawn bonds were often evident, with bonds going to the H in a methyl group in the side chain.

(iv) Responses were uniformly poor — few were able to link the three ideas: length of non-polar carbon chains, polarity, and hydrophilic/hydrophobic character. This question found many students incorrectly discussing dispersion forces (based on an erroneous molar mass argument), rather than the relative polarities of the chains and hence strength of secondary interactions. Only the very best answers clearly articulated the relationship between the greater non-polar component of PHBV (whether through the longer side chains or the presence of two carbon atoms between the ester links in the chain), compared with Ingeo™, and the resultant difference in hydrophilic/hydrophobic character. While hydrogen bonding of polar water molecules with the carbonyl oxygen of the ester group was identified by many, it was a very rare student who recognised that both oxygen atoms in the ester group are capable of forming hydrogen bonds with water. Some responses were vague, referring to the greater size (or mass) of PHBV, a factor that is unknown without knowledge of the chain length. A disappointing number of students nullified good points by contradictions; for example, describing non-polar groups as 'hydrophilic'. A significant number focused on the structures of the monomers and discussed hydrogen bonding with carboxyl and hydroxyl groups in the monomers.

Question 2

(a) (i) Few students knew the names of both pieces of glassware. Many recognised the condenser (B), but most students were unable to correctly name A as a dropping or separating funnel; it was most commonly referred to as a 'burette' or 'volumetric burette'. 'Condensing tube' and 'cooling tube' were other responses for B which were not given credit.

(ii) Many students realised that the purpose of the glassware was to cause condensation, but were unclear about what was being condensed (the aldehyde); incorrect responses mentioned 'the alcohol', 'the solution', 'the reactants', and 'the ester'. Many students referred to *cooling* the vapours or gases, as distinct from *condensing* them.

(iii) Approximately 75% of students answered this correctly, with water being forced to flow against gravity, although a number of students did not answer the question.

(iv) This question was usually answered correctly, with students describing the function of boiling chips as 'promoting even boiling'. A few explained that they provide a surface upon which small vapour bubbles can form, so helping to prevent super-heating. However, a significant number of students described the chips' effect on heating rather than on boiling. A small number thought boiling chips to be catalytic in action.

(v) (1) Usually this was answered successfully, although a significant number of responses included 9 e^- or omitted the 2 Cr^{3+}. Given the frequent reference to this half-equation in the subject outline, a surprising number of students had little idea of how to tackle the question.

(2) Lack of acid for the oxidation to occur was correctly identified by a minority of students. Even the few students who recognised the need for acid often identified it as a catalyst. Most students believed that absence of heat was the problem.

(vi) Almost all students gave the correct response. A very few gave acidified dichromate, and some of those did not give an appropriate colour change. There were some interesting spellings of 'Tollens' reagent'.

(vii) Not answered well, with many simply stating the *difference* between the two diagrams (for example, use of thermometer, or use of ice-cooled flask), rather than the *advantage* of the difference. Many students stated that the thermometer could be used to control the temperature or to prevent further oxidation to the acid. Recording the temperature of the reaction mixture, the alcohol, or water vapour were variations that were not given credit. Responses that referred to minimisation of evaporation of the distillate led to better answers, although very few referred to the minimisation of fire hazard. Answers were frequently poorly expressed — lacking in clarity, particularly with respect to the role of the thermometer and its specific purpose. While it might be suspected that imprecise expression was to blame rather than of lack of understanding, such answers were penalised.

(viii) While most correctly identified the carboxyl group, common wrong answers included esters, ketones, carboxylates. and even amines.

(b) (i) Very well done, although, as mentioned in the general observations above, the uses of hyphen, capitals, commas, and spacing tended to be random rather than following IUPAC systematic nomenclature. The inclusion of the number '-1-' to identify the position of the aldehyde group (that is, 3-methylhexan-1-al) was common but was not penalised.

(ii) Very well done, even by those who gave incorrect responses in part (i). However, a small number of structures were aldehydes, sometimes the same as the one given in part (i). Students need to be careful with drawing bonds in structural formulae, and with the number of bonds formed by each C atom.

Question 3

(a) (i) Most responses gained 3 marks of the possible 4. The naming of butanoic acid caused few problems, although a few students named it propanoic acid. However, heptan-2-ol was most commonly named 1-methyl-1-hexanol. A few responses confused the acid and alcohol components. As with the aldehyde in Question 2(b)(i), the number '-1-' was unnecessarily included in the name 'butanoic acid'. Again, lack of knowledge of the correct IUPAC 'punctuation' of organic nomenclature was evident.

(ii) Most students identified the catalyst correctly.

(b) (i) Most students were able to state the molecular formula of camphor as $C_{10}H_{16}O$, and hence arrive at the correct value for the relative molecular mass. In a few instances an incorrect number of H atoms was deduced and an appropriate calculation performed. However, a reasonable number of students appeared to have spent a great deal of time working backwards from the molar mass to find a combination of 16.00, 12.01, and 1.008 that would add up to 152.2. Others wrote an incorrect formula and stated that this resulted in a relative molar mass of 152.2.

(ii) (1) Some students did not recognise the need to convert milligrams to grams (mg to g), while others who saw the need were unable to complete the conversion correctly. Consequently, a wrong answer of 30% was common. A variety of methods were used leading to correct and incorrect answers, with some attempting to determine the number of moles of camphor present in 3 mg.

(2) More students were successful with this calculation than with part (1). Strangely, many students who had failed to convert to grams in part (1) did so here.

(iii) (1) Usually correctly answered.

(2) Few students gained full marks for this question. Common misconceptions included describing the presence of three electron pairs around the O atom; repulsion between atoms, rather than electron pairs;

and the belief that polarity and differences in electronegativity influence molecular shape. Some students omitted the essential point that, while four electron pairs adopt a tetrahedral arrangement, the presence of two unbonded electron pairs results in the atoms assuming a V-shape. Consequently, students concluded that the four pairs repel to take up a V-shaped arrangement. It may be that many students did understand the concept, but their poor expression cost them marks. Many students could gain 2 marks but were unable to explain the V-shaped arrangement of atoms. Although this type of question is common, few students were well prepared for it.

Question 4

(a) (i) This was usually well done, although a few students failed to include reference to the qualifying phrase 'at room temperature'. Many students included knowledge that was not relevant to 'physical property', such as fats mainly being from mammalian origin and oils being from plant and fish origin. A significant number described, in detail, the effect of saturation/unsaturation on the ability of chains to stack together, but did not then go on to actually state the resultant difference in physical property.

(ii) Usually done well. The incorrect use of the word *clear* for *colourless* was less frequent than in previous years but was still evident. Many students wrote 'no reaction' as an observation. Students must identify the actual observation — that the orange/brown colour persists. There were a few responses of $KMnO_4$, some of which then went on to give the correct observations.

(iii) Many students stated the anionic component only. Too many students who wrote an extended structure fell into error with the number of C atoms. The occasional carboxylic acid structure occurred, and students who indicated a covalent bond attaching the Na to the O atom were penalised.

(iv) There were many correct responses. However, many responses referred to 'polar ionic' heads or 'polar anions', which were penalised since a species can be either charged *or* polar. Other students confused 'heads' and 'tails'. A significant number referred only to the hydrophobic component of soaps and detergents and failed to mention the hydrophilic component. On the other hand, many students went on to describe the action of soaps and detergents through the formation of micelles, which was not required.

(b) (i) Mostly correct, although most of the listed ingredients appeared as answers. The most common wrong answer was sodium carbonate.

(ii) (1) Although most students gave correct responses, many referred to cation exchange without addressing the required point; that is, the composition of the water. There were many vague answers, such as 'the hard ions are removed' which failed to indicate any understanding of what these ions were. Among wrong answers, the most common described the removal of the metals calcium and magnesium, rather than a decrease in concentration of their ions.

(2) (A) A pleasing number of students were able to draw the cyclic tripolyphosphate anion correctly. Strange structural formulae were given showing P with a covalence varying from 2 to 6; O forming

only one covalent bond, yet without the negative charge necessary to complete its octet; and Na forming from one to four covalent bonds. Even correctly drawn structural formulae often included the sodium ions, although the anion only was sought. A few instances of the linear form of the ion (often incorrect) were observed.

(B) About half the papers correctly identified the tetrahedral arrangement even if there was no structure given for the polyphosphate ion.

(3) Correct equations were commonly written, although a significant number of copying errors resulted in one incorrect formula and hence no credit at all for the equation. A significant number of students attempted to include O_2 as a reactant in the equation.

Question 5

Unexpectedly, this was the most poorly done question in the paper, with a mean of 44% compared to a mean of 58% for the examination as a whole. The questions, in themselves, do not appear to be difficult, but students were required to move between a number of different topics of the subject outline.

(a) This was poorly done, with relatively few students gaining 2 marks. Many students did not refer to the difference in reactivity between Al and Fe, and, of those who did, many said that either the oxide was easier to reduce, or Fe was easier to reduce rather than Fe^{3+}. A number of students incorrectly used Fe^{2+}, even though the question mentioned Fe_2O_3. A number of students referred to an 'it' that would be reduced.

(b) (i) Only about 50% of students were able to write a correct equation, as most did not know, or were unable to deduce, that AlO_2^- (or $NaAlO_2$) is a product. A number gave $Al(OH)_3$ as a product.

(ii) Although most students gained some marks for this question, there were some who based their answer on relative positions of elements in the reactivity series rather than the nature of the oxides. Many students, possibly in an attempt to be concise, referred to both aluminium oxide and silicon dioxide as amphoteric oxides, while others stated that, as Si is a metalloid, SiO_2 is an amphoteric oxide. A few students neglected to mention that NaOH is a base or that the reaction was an acid–base reaction.

(iii) (1) Many students were able to answer this question correctly, although some students clearly did not understand how to find the pH of an alkaline solution. The calculation of $[H_3O^+]$ instead of $[OH^-]$ was a common mistake. Most students received either 0 or 3 marks for this question.

(2) (A) This question was not well done. Some students produced a convoluted solution involving moles and molar mass.

(B) Generally well done. Many students understood the concept of ionic attraction, although several students simply mentioned cation exchange without enough detail. Some students mentioned only one charge, either on the clay or the mercury ion.

(c) Very poorly answered. Very few students correctly identified the lack of moving ions as the reason for the lack of conductivity in solid Al_2O_3. Most commonly, students identified the lack of free electrons as the reason for lack of conductivity.

Question 6

(a) (i) This question was generally well done, although some diagrams had the activation energy and enthalpy incorrectly labelled.

(ii) (1) Less than 50% of responses gained full marks, usually because they lacked an explanation in terms of the activation energy. A significant number of students incorrectly discussed the effect on the *number* of collisions rather than the *frequency* of collisions, and some answers focused on the effect of an increase in temperature. Many responses simply commented on the decrease in kinetic energy of particles. Some students did not read the question carefully and gave an answer related to an *increase* in temperature, while others mistakenly tried to answer in terms of Le Châtelier's principle.

(2) Many students understood how to use Le Châtelier's principle to answer this question very well, but failed to mention the disadvantage to the manufacturer. A significant number of students only mentioned the cost of increased energy associated with the higher temperature to the manufacturer. Some responses stated that the catalyst would be denatured, suggesting a belief that all catalysts are proteins.

(iii) Common mistakes included wrongly assigning the state of methanol as a gas or an aqueous solution. Other students doubled the equation but failed to double the value of ΔH. A small number of students wrote the equation for the formation of methanol as given in the table at the start of the question.

(b) (i) Mostly well answered, although some responses simply mentioned the three-dimensional or honeycomb structure without recognising that this provided a large surface area.

(ii) (1) Generally well done.

(2) Very few responses gained full marks for this question because many students did not realise that aluminium atoms are part of the aluminosilicate anion structure, and if they did identify that Al was covalently bonded to Si and O atoms, they could not explain why Al cannot be replaced by Ca^{2+}. Several students believed that it was the higher charge on an Al^{3+} ion that prevented it from being replaced.

Question 7

(a) (i) Most students answered correctly, although some confused the amide group with the amino group. A small but significant number of students gave two answers, one of which was incorrect, and therefore received no mark.

(ii) Many students were able to obtain 1 or 2 marks for this question, but few gave a comparison between the strength of the ion–dipole interactions and the previously existing hydrogen bonds, which was necessary to gain the full 3 marks for the question.

(b) (i) Most students answered this question correctly ('amphoteric'), despite the spelling sometimes being incorrect.

(ii) Many students were unable to write the correct formula for zirconium sulfate ($ZrSO_4$), with $Zr_2(SO_4)_4$ and $Zr_2(SO_4)_2$ being common errors. Some students did not read the question and used HCl as the acid.

(c) (i) This was reasonably well answered. Some responses discussed ion–dipole and hydrogen bonding but did not mention the many specific groups present that are involved in these interactions.

(ii) (1) Most students answered this correctly with the most common incorrect answer being 'carboxyl'.

(2) Few students answered this correctly. Many students did not follow the instructions to number from the – $COO^{-}Na^{+}$ group. The most common incorrect answer was 2 and 5.

(d) (i) Most students answered this question correctly, although misspellings were common.

(ii) (1) Most equations were correct, with the most common error being the formation of Zn or Zn^{2+} rather than ZnO as a product. Some students did not get the gas correct, with SO_3 given a significant number of times.

(2) Very well done, with most being able to identify acid rain. However, there were a few incorrect responses that mentioned the (enhanced) greenhouse effect or photochemical smog.

(iii) Generally well done, although some students named the process, electrolysis, rather than the type of cell.

Question 8

The mean for this question, 50% compared to the examination mean of 58%, was the second-lowest question mean for the examination. Perhaps, more than other questions, this one required correct use of chemical terminology in almost every part. If chemical knowledge is to be communicated effectively, it is essential that students know the meanings of chemical terms used and have extensive practice in using them precisely.

(a) Most students were able to gain 2 marks in this question. A number of students were able to identify the triple covalent bond in N_2, but were not able to relate this to solubility or to the large amount of energy required for its reaction. Some students did not explain why the nitrogen needed to be in soluble form.

(b) Generally well answered. Some students confused the ammonium ion (NH_4^+) and ammonia (NH_3), using various combinations of the two, such as 'NH_4 (ammonia)'.

(c) (i) (1) Most students gained 3 marks for this question. Students who gave the answer 'least polar' talked about the 'polar stationary phase', showing a failure to read the question carefully.

(2) Many students did not understand that the structural formula of the amino acid, and not a section of the protein chain, was required. Some students were unable to select the appropriate amino acid, indicating an incomplete understanding of the polarity concept.

(ii) Most students were able to identify a non-polar side chain, but a significant number included part of the main chain in their circle rather than just circling the side chain, while others chose an incorrect side chain. On the whole, the circling was not well done, as students often excluded parts of letters or numbers or drew up to three circles.

(d) This extended-response question was not well answered, with very few students obtaining full marks. The majority of responses displayed a very poor ability to communicate the concept in the first part of the question. Many students correctly identified where hydrogen bonds formed between two functional groups or gave a definition of a hydrogen bond, but did not explain how a hydrogen bond forms, thus indicating that they had not read the question carefully. It was common for students to discuss fluorine–hydrogen bonds, although there was no fluorine in the molecule. It was unclear in many responses whether they were talking about the polar bond between covalently bonded O and H atoms or a dipole between the O and H atoms in two different parts of the molecule. Some students talked in terms of full charges rather than partial charges, while several drew a hydrogen bond to a sulfur atom. A common error in the second half of the response was for students to state that increasing pH would increase the concentration of H^+ ions, hence protonating the amine groups. Most students could state that hydrogen bonds would be disrupted and that the shape would change. However, most students did not correctly explain how this happened.

Question 9

(a) Well done. Nearly all answers referred to incomplete combustion or insufficient oxygen

(b) Many students gave a correct answer, although a multitude of units were used. Too many failed to convert kilograms to grams.

(c) (i) Not well done. Too many students did not identify the need to include electrons in the half-equation but treated it as a full equation. Hydrogen gas was therefore identified as a product instead of H^+.

(ii) Reasonably well done, although many students wrote 'anode' which did not answer the question.

(d) (i) Students generally answered very well or very poorly, with few in between. Answers were often in terms of a displacement reaction in which CO displaced oxygen and therefore it must have bonded more strongly with the haemoglobin, failing to use the K_c value. There were numerous answers which were written as though students failed to notice that the reaction was one of equilibrium.

(ii) Many students failed to relate their answer to a shift in equilibrium. To obtain full marks in such questions, a logical sequential approach is needed; answers were often lacking in this regard. Some attempted to answer the question from a physiological point of view and ignored the equilibrium chemistry.

(iii) (1) Generally well done, although a few responses showed addition of equilibrium concentrations rather than multiplication, and a small number inverted the expression.

(2) Generally poorly done, with a high proportion of students unable to use the K_c expression and the values for [CO] and [O_2] to determine the value of the [HbCO]/[HbO_2] ratio. Many students gave an informed answer to whether breathing the air would be fatal or not, even when the mathematics was inadequate.

Question 10

(a) A variety of answers were given which clearly indicated that some students had not read the introduction and/or they had no knowledge of what ammonia is. Common incorrect answers included 'tie hair back' and 'don't drink it'. Some generic answers which addressed general laboratory safety rather than this particular situation earned no marks.

(b) (i) (1) Generally only done well in papers that were of a consistently high standard. 'Pipette' was the most common incorrect answer.

(2) Generally not well done. 'Water' was the most common incorrect answer.

(ii) Very poorly done with 'random errors', 'systematic errors' and 'incorrect washing' some of the incorrect answers. While this suggests weakness in the ability to analyse data (specific feature AE3), it may indicate a failure to read introductory information in a question. As mentioned in some earlier questions, a failure to apply their knowledge to this particular situation was the most common reason for students not gaining any marks. A large number of students described the ammonia as 'evaporating', which suggests a misunderstanding of change of state or a belief that ammonia solution is pure ammonia.

(c) Calculations were either done very well done or very poorly. Conversion of millilitres to litres (mL to L) was often confused, or ratios were incorrectly applied (or, in some instances, not used). A very small minority of students were able to undertake six calculations and write all answers to the correct number of significant figures; it was suspected that many students had made no attempt to ensure the correct use of significant figures. The first four parts were done correctly by many students. A common error in attempting part (v) was the failure to use the correct dilution factor with many using 250:25 instead of 250:20. A common error in part (vi) was the failure to realise that the number of moles calculated in part (v) as being present in 250.00 mL was the same number of moles as in the original 25.00 mL. It appeared that many students used a corrected value for later calculations rather than maintaining the uncorrected value in their calculator for subsequent calculations.

Question 11

(a) While approximately one-third of the students answered correctly, many gave the electronic configuration of Fe, while others, in making the adjustment from Fe to Fe^{3+}, took three electrons from the 3d subshell rather than two from the 4s subshell and one from the 3d subshell. A small but significant number of students showed the number of electrons in a subshell as a subscript instead of as a superscript; for example, $1s_2$ instead of $1s^2$.

(b) (i) This equation was very poorly done. In many papers a blank space was left. Many could not write a correct formula for arsenic(III) oxide, while others did not add water and many failed to balance the equation.

(ii) This was very poorly done. Students appeared unable to make connections with information supplied or were distracted by the +3 and +5 oxidation states. Students who observed the attraction between ions for the +5 species failed to comment on the attraction between Fe^{3+} and the uncharged molecule.

(c) (i) Most students found this question very easy for gaining marks, with few responses receiving less than 3 marks. The most common errors were misplacement of the axes and the careless drawing of the line of best fit.

(ii) Responses were variable, with some very good answers but few receiving full marks. Some responses cited incorrect or inaccurate data, while others had trouble using the data provided to draw a conclusion.

(iii) While most students were able to gain at least 1 mark, some answers were imprecise in describing the change made to the lamp or solutions. The failure of students to apply general theory to a specific situation has been mentioned elsewhere in this report.

Question 12

(a) (i) Answers to this question demonstrated again the failure of many students to correctly use chemical terminology. Many students did not mention electronegativity, which made answers very difficult to follow and usually led to loss of at least 1 mark. What should have been a straightforward application of a very familiar concept was done badly.

(ii) Many descriptions seemed to be generic explanations of why molecules are non-polar, rather than applying the appropriate chemical terminology to the specific instance. Very few students mentioned dipoles, while a surprising number gave the wrong shape of the CO_2 molecule. Many students stated as a reason for non-polarity 'it is symmetrical'. There appeared to be little understanding that this statement is insufficient or that some polar molecules have an axis of symmetry.

(b) (i) Generally answered well, even when the rest of the question was poorly done.

(ii) Fairly well done, apart from those students who lost marks for careless application of units. A minority of students failed to place the independent variable in the first column of the table.

(c) Students found many ways to gain marks in this question, with some students writing outstanding answers, while others appeared to be guessing in the hope that some correct chemistry might be found in their answers. Some of the poorer responses described ocean warming because of extra carbon dioxide, eutrophication in the ocean, loss of sufficient of carbon dioxide in the atmosphere, and an Earth being overtaken by algae.

OPERATIONAL ADVICE

This was the first year in which all school assessment was moderated centrally. Some teachers included extensive details of how they assessed each piece of work. The moderation of student work is facilitated by submission of original student work rather than scanned copies submitted via digital media.

Most packages of student work were packed by assessment type and labelled clearly, which helped to make moderation more efficient. Having the grade level for each assessment type clearly marked on the bag for each student was also expedient. Occasionally pieces of work were missing and the Variations in Materials for the Sample for Final Moderation form from the learning area manual was not included. These omissions made the moderation process more difficult. Some schools submitted more than the nine summative tasks specified in the subject outline. In some sets of materials, tasks did not comply with the approved learning and assessment plan or different tasks were submitted without being noted in an addendum. Occasionally the tasks varied between students, again without the use of an addendum or a Variations in Materials for the Sample for Final Moderation form to indicate that special provisions had been enacted. This practice made it more difficult for moderators to confirm the teacher's assessment judgments.

It was pleasing to see many instances where teachers shared assessment tasks and marking in combined classes so that the performance standards were applied consistently. However, there were instances where consistent application of the performance standards was not evident across the group when two or more classes were combined. There were some cases where, although common tasks had been set, differences in application of the performance standards (for example, in marking tests) led to inconsistencies in grade assignment. It is recommended that the combination of teaching groups for assessment purposes involves sharing both of assessment tasks and marking.

Chief Assessor
Chemistry