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Chemistry

2015 Chief Assessor’s Report

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## Overview

Chief Assessors’ 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

General Comments

Teachers have generally been able to consistently apply the performance standards to student work when determining grade levels.

Grades were adjusted at moderation mainly due to task design or inconsistency in the way that evidence was aligned with the standards. Some tasks limited students’ opportunities to demonstrate evidence in the upper A grade levels particularly in response to certain criteria. Most noticeable were the lack of difficult questions — particularly applied to specific features AE1, AE2, and A1 — and the limited scope for students to expand upon their understanding.

Assessment Type 1: Investigations Folio

Practical Investigations

Many practical reports were completed with thorough detail and preparation. Assessment conditions ranged from completion entirely under supervision, to examples produced entirely out of class time. This variety of conditions led to diversity in the style of reports. Moderators noted that some reports were excessively long, and that students should be reminded that extra words do not always add to the quality of the report. It was also noted that the readability of a piece was diminished when students attempted to include every aspect of their knowledge and understanding in the introduction or discussion sections. This made it difficult for them to achieve an A grade for communication.

While scaffolding in tasks gave some students a guide for discussion, it limited the ability of other students — particularly in the A grade band — to elaborate on their understanding and reasoning. The limited space provided for a response on some task sheets also penalised these students unnecessarily. A balance must be sought in the tasks between providing some guidance, but still giving students the opportunity to convey the extent of their understanding and skills in analysis and evaluation.

Students generally gave a detailed discussion of errors and improvements, but many did little more than list the same generic statements in each task. Examples of best practice often discussed a smaller range of errors that were clearly relevant to the chosen activity, had an impact on the data collected, and were evident in the results obtained. Some confusion remains regarding the distinction between random errors, systematic errors, and mistakes in the application of techniques or selection of faulty equipment. It was also noted that some students included an errors analysis in all three practical tasks, which is unnecessary and inappropriate in some tasks.

Teacher checklists or comments for specific features A3 and I3 give evidence of manipulative and work skills, but sometimes these were not provided. Without these forms of evidence it was difficult for moderators to confirm grades, particularly when the results or discussion indicated lower standards. Some tasks included a useful student discussion of how collaboration led to greater confidence in results and effective time management.

Current requirements for the organic preparation have limited most investigations to an ester preparation, and moderators noted the similarity in task design across schools. However, the titration investigations used a range of contexts, often analysing quantities in everyday substances.

It was pleasing to see a stronger emphasis in many schools on performing a preliminary phase in the design investigations. This led to greater student autonomy and a more authentic attempt at design. Once again, students were disadvantaged if the investigation did not allow opportunities for design or they were not given the scope to explore their understanding in the discussion and analysis.

Issues Investigation

Tasks were generally presented as an essay-style report, with an accompanying evaluation and consistent acknowledgment of sources, covering a wide variety of issues.

Once again, achievement was limited when students were allowed to pursue a topic rather than an issue. When students are formulating their question, they should check their sources for relevant chemistry and differing points of view. The chemistry selected needs to be more than just related information; rather, it should help to explain at least one side of the argument. Students must be warned against simply collating groups of referenced or paraphrased material, without the construction of suitable arguments required to formulate a reasoned conclusion.

Although the use of a summary table is not a requirement for the evaluation of sources, moderators noted that it was often used to effectively categorise information. Use of colour-coded highlighting of sources for bias, credibility, suitability, and accuracy effectively limited the impact of annotations on word count. Few examples were found to exceed the word count of 1500 words.

Assessment Type 2: Skills and Applications Tasks

Once again, less adjustment was evident for this assessment type, and tasks were generally well-constructed and based on the structure of past examinations. Tasks demonstrated very little deviation from traditional tests performed under supervision. The number and length of tasks varied, but generally consisted of one task per topic. Some tasks were unnecessarily long. It should be noted that not all key ideas and intended student learning are required to appear in the set of tasks. The inclusion of a trial examination had a negative impact on achievement in a large number of cases because of the extra difficulty of such a task compared with shorter tests.

Examples of best practice demonstrated inventive use of past questions, ranging in difficulty and style, with novel attempts at generating new questions in both familiar and unfamiliar settings. Although the set of tasks may show a progression in difficulty over the year, moderators occasionally noted some sets of tasks that barely elevated past a Stage 1 standard. Tasks that rarely used discriminating questions prevented students from achieving in the upper A grade levels.

Although marks are commonly applied in this assessment type, it is important that evidence is considered against the performance standards, rather than the percentages obtained. The set of tasks must include questions that address specific features from all four assessment design criteria.

Although the structure for this assessment type does not have to match the examination, moderators thought that it would be beneficial for students to attempt at least one example of extended writing as an extended response. The use and benefit of multiple-choice questions was also queried.

## External Assessment

Assessment Type 3: Examination

As always, the student cohort represented the full range of achievement with an examination mean of 58%. It was pleasing to see many well-considered responses, especially to those questions set in unfamiliar contexts.

For some students, poor expression affected the clarity of their response and reduced the marks they could receive. For others, very small or untidy handwriting made some responses difficult to read. Students should be reminded that marks cannot be assigned if the meaning is unable to be deciphered. They are also encouraged to use pencil to draw neat and accurate diagrams and graphs.

Students need to be specific in their responses to short-answer questions. Simply stating words such as ‘slope’ in Question 1 (a) (ii) (1) or ‘scatter’ in   
Question 12 (a) (iii) provided insufficient information to be awarded a mark. Students must also read the question carefully so that they answer the actual question. For example, Question 9 (c) required students to comment on the calculated percentage of PbCO3, but many related their response to the true percentage in the ore.

Students are encouraged to practise writing answers to questions that require an explanation of concepts, so that they can improve their ability to express themselves correctly and precisely under pressure. Concise answers are best and incorrect information in responses is penalised.

Many students had difficulty with calculations that involved unit conversions, rearrangement of formulae, rounding errors, and determining the number of significant figures to be used. Several students struggled to balance equations and use correct formulae for chemical species. Students and teachers are reminded that this is an essential communication skill in chemistry that is regularly assessed.

Question-specific Comments

Question 1

(a) (i) Most responses for this question earned at least one mark. Students often explained that the catalyst provides an alternative pathway of lower activation energy so that more molecules have the required energy on collision. However, many then referred to an increase, rather than to an increased frequency, of successful collisions. Some responses lacked any reference to successful collisions. Many students believed, incorrectly, that the presence of a catalyst leads to an increase in the number of collisions of reactant molecules.

(ii) (1) Most students identified the increased slope as the appropriate feature but some simply identified the slope without explaining that A was steeper than B. Some students described the higher percentage conversion for A, rather than the feature of the graph.

(2) A surprisingly small number of responses recognised that the reaction had reached equilibrium. Responses to this question most commonly referred to the reaction being complete or all the reactant used up, even though only 80% of the oil had been converted to biodiesel. Others believed that the reaction had stopped, while a significant number demonstrated a poor understanding of catalytic action in stating that the supply of MgO was exhausted.

(iii) Many responses earned full marks by explaining that the increased energy led to disruption of secondary interactions holding protein chains in their 3D shape, and this change in shape resulted in loss of function of the enzyme. Students most commonly lost marks through failure to link increased energy to the disruption of secondary interactions between groups in the chain, or through reference to the breaking of bonds in the enzyme, implying that primary bonds within the protein were disrupted. A few responses discussed changes in the shape of the oil rather than of the enzyme.

(b) (i) (1) The number of atoms in this structure was usually correct, but common errors included the number and position of charges, and the absence of double-bonded O atoms and of the O links. A significant number of students drew a cyclic structure, while others represented a continuous polymer chain.

(2) The most common response to this question was ‘fertilisers’. As the question required a statement of a human activity, ‘use of fertilisers’ was the appropriate answer. This is an example where communication skills in a response are important. A large number of students believed that the burning of fossil fuels leads to increased phosphorus levels in waterways, while others merely repeated information about detergents given in the question.

(ii) (1) Many students failed to read the question correctly and therefore responded with an incorrect answer of ‘basic oxide’.

(2) Many students were unable to write correct formulae for the species involved, and even fewer students could correctly balance the equation. Again, a significant number did not read the question carefully, and attempted to write the equation for the reaction of magnesium ions with the tripolyphosphate ion.

(iii) This question was generally answered well. Students recognised that aerobic decay of algae uses up oxygen dissolved in the water, or that surface algae block sunlight so that plants below are unable to produce oxygen through photosynthesis.

Question 2

(a) An increase in the rate of the reaction was correctly stated by most students, although poor reading of the question led to references about yield rather than rate.

(b) Many students obtained full marks for this calculation. Others correctly identified the mole ratio but were unable to use this to deduce the number of moles of the alcohol. In problems such as this, students are encouraged to present their reasoning clearly, in order to receive some marks for partially correct calculations. If x and y are used in the calculation, the species described by each variable must be clearly identified.

(c) (i) Most students answered correctly, recognising that the yield would decrease.

(ii) Poor communication skills were evident in most responses to this question. Although the question required students to use information from the table in their explanation, many failed to do this. The best responses explained that the lower Kc value at the higher temperature indicated that the reverse reaction was favoured at this temperature, and correctly identified the reverse reaction as endothermic. Responses that explained in terms of the forward reaction were often confused and repetitive.

(d) Many students took the opportunity to demonstrate an excellent understanding of the relevant chemical concepts in this response. However, a significant number confused the concepts and attempted to explain increase in yield in terms of collision theory, and increase in rate in terms of Le Châtelier's principle. Also the reasons for using moderate pressures were frequently general and vague, with ‘cheaper’ and ‘safer’ often offered without any elaboration.

Some responses were marred by poor spelling and grammar, with the spelling of ‘yield’ causing particular difficulty. Use of paragraphs would have assisted in the logical presentation of the three parts of this response, but few students chose to do this.

Good responses addressed the following points:

* Increased pressures lead to increased frequency of successful collisions and hence to a desirable increase in the rate of reaction.
* Increased pressures caused the system to shift to the right, opposing the increase in pressure by favouring the reaction that forms fewer moles of gas particles. Thus product yield is increased.
* Despite these advantages, use of high pressures leads to increased manufacturing costs. This is due to special and expensive equipment being needed to contain the high pressures, and the costs of maintenance which are high.
* There are also safety issues for workers, with increased risk of explosions at high pressures.

Question 3

(a) (i) This structural formula was generally drawn correctly. Marks were most commonly deducted for errors in the number of C or H atoms or for missing –O– links in the ester group. Students who drew out the extended structure showing all bonds needed to take care that bonds were placed correctly between the bonded atoms.

(ii) This was well answered, with water identified as the other product of the reaction.

(b) (i) This was mostly answered well, although ‘hydrolysis’ and ‘polymerisation’ were not uncommon incorrect answers.

(ii) Most responses correctly stated that the product of the reaction would be more solid, or would have a higher melting point. Few students went on to link this change to greater consumer convenience such as a product like margarine that can be spread or will not spill, or is easier to store and transport. Vague references to the product being ‘healthier’ were frequent. Others clearly confused the product with thermosetting polymers, describing it as rigid and brittle.

(c) (i) This calculation was generally well done, although many omitted ‘x 10-6’ in the final answer. A few students were not familiar with the correct formula to use.

(ii) Most students realised that oleic acid was present. ‘Water’ was the most common incorrect answer.

(d) (i) (1) Students generally drew the correct structure for the carboxylate ion.

(2) Most responses demonstrated a good understanding of the concepts, but poor language skills often led to confused explanations. In particular the ionic head of the ion was often described as polar, which did not lead to a logical comment about ion-dipole interactions with water. Many students chose to continue their explanations to include the formation of micelles, resulting in a response longer than necessary for the number of marks allocated.

(ii) Most could convert 1 L to 870 g of biodiesel and continue the calculation to arrive at a correct answer. A few students divided, rather than multiplied, by 37.8. Some answers failed to include a correct unit and many ignored the correct convention for representing kilo (k) and joule (J).

Question 4

(a) (i) Most responses identified ‘carbohydrate’ as the correct response.

(ii) Although generally drawn correctly, the hydroxyl group was sometimes placed in the primary position, and an aldehyde group sometimes replaced the carboxyl group. Poorly placed bonds caused some students to lose a mark.

(b) (i) Most answers indicated the correct group.

(ii) (1) Most students correctly indicated the proline residue.

(2) The secondary amine in the proline residue confused some students and this structural formula proved difficult to draw correctly. Many made no attempt to draw the amino acid. The most common errors included an extra H on the N, and the complete absence of the carboxyl group.

(iii) (1) Most students obtained full marks for this question. A few labelled the hydrogen bond indicated in part (2) rather than, as instructed, the bond in the rectangle. Others drew a symbol that was not recognisable as .

(2) Most responses correctly identified the hydrogen bond.

(iv) Most answers correctly recognised that the strong, covalent cross-links between the chains make the new polymer more rigid. However, few then continued to explain that this strong bonding prevents the chains from sliding over each other, or to compare it with the unmodified polymer which has only weaker hydrogen bonds between the chains.

Question 5

(a) (i) Most responses correctly identified the cell as being electrolytic.

(ii) A large number of responses correctly identified the electrode to be negative. Poor interpretation of what the question was asking resulted in students naming it as a cathode or anode, or identifying it as the site of reduction.

(iii) (1) Approximately half of the students did not achieve the full mark. Common errors included no electrons in the equation, electrons on the wrong side of the equation, and converting Al to Al3+ in an attempt to balance the charges.

(2) Students who were able to give a correctly balanced equation in part (1) were able to correctly identify the electrode as the anode.

(iv) Few students were able to achieve full marks for this question, with many responses lacking an explanation of the stated shape. Some students incorrectly identified the shape to be square planar. Many responses failed to identify the regions of bonded electrons and that there were no regions of unbonded electrons around the S atom. Many students correctly identified repulsion between O atoms as associated with the shape, but were under the misconception that the negative charges on two of the atoms had a greater influence on the shape.

(b) (i) A minority of students gave a correct response. Most common incorrect responses were +4, +10, and -2.

(ii) Errors made in part (i) were often carried through to this question. Many students did not identify the 4s subshell as the highest energy level in the cobalt atom and therefore removed electrons from the 3d subshell when writing the electron configuration for the ion. Students are reminded that lower case is used for s, p, d, and f subshells.

(c) (i) This question was poorly answered, with very few students attaining full marks. Using the wrong formula for the oxyanion and incorrect balancing of the equation were the most common mistakes.

(ii) Many students were able to identify a disadvantage. Again, misinterpretation of the question caused a number of students to incorrectly identify scum formation and the action in hard water as a disadvantage for washing the objects in a dishwasher.

Question 6

(a) (i) (1) As in past examinations, the writing of this required equation was not well done by a number of students. Many students incorrectly identified the formula for nitric acid as H2NO3.

(2) A number of students did not make the link between this question and part (1). Many students missed the connection between stronger acids and their subsequent complete ionisation leading to an increased concentration of H+ in acid rain.

(ii) The most common correct response was an oxide of sulfur. However, a large number of students incorrectly stated that carbon dioxide was a contributor to acid rain.

(b) (i) The majority of students were able to write a correctly balanced equation. Some students attempted to include state symbols that were not required.

(ii) (1) Many students correctly identified Al2Si2O82-. Errors were mostly in the charge or the subscripts.

(2) No calculation was necessary to answer this question, yet the majority of students attempted to use mathematical processes, often resulting in answers other than 50%.

(iii) Few students achieved full marks for this question. Many students focused their discussion on the role of the clay, rather than the intended exchange of ions between the clay and river water. Often, students failed to relate their responses to Le Châtelier’s Principle. A number of responses failed to draw a conclusion about the effect of acid rain on the river water in the given scenario. Many responses were poorly expressed.

(iv) Most students achieved one mark by identifying either an increase in the concentration of hard water ions or the formation of insoluble scum as a disadvantage. Few responses explained the relevance of their first statement to domestic water supply.

Question 7

(a) The majority of students correctly identified the molecular formula to be C8H10N4O2. Most common errors included a wrong number for one of the elements or leaving out one of the elements, particularly N or O.

(b) (i) This question was answered correctly by the majority of students. The most common incorrect response was ‘secondary amine’.

(ii) Approximately half of the students identified the absence of a carboxyl group. Some incorrect responses included hydroxyl, carbonyl, or the presence of sulfur.

(iii) Generally, the structure was drawn correctly. The most frequent errors included writing the positive charge on the H atom instead of the N, or leaving the acidic H atom on the carboxyl group.

(c) (i) (1) Most students correctly identified maltose.

(2) This question was generally well done, with many students obtaining full marks. The best responses demonstrated concise, logical progression of ideas, linking the polarity of the sugar with the polar solvent and the shortest retention time. The most frequent inaccurate response stated that glucose was the most polar because it had the greatest area under the peak, a feature related to concentration and not retention time.

(ii) (1) A significant number of students used an incorrect molecular formula for glucose or added reagents other than water to the equation.

(2) Most students recognised that the maltose peak would be absent because all maltose had been hydrolysed.

Question 8

(a) The simplest successful responses acknowledged that 10 hydrogen atoms would be required to completely saturate retinol, thus adding 10.08 g to the stated molar mass. Some students based their calculations on their own incorrectly derived molecular formula.

(b) (i) This question was well answered, with most students identifying the non-polar nature of the hydrocarbon chain. A common error was to identify the cyclohexene ring component in retinol as a benzene or aromatic ring.

(ii) The majority of students achieved at least one mark by identifying   
propan-2-ol as the more appropriate solvent. Further marks were achieved if students linked this to the presence of the hydrocarbon section of   
propan-2-ol. Most students did not acknowledge or explain the secondary interactions between propan-2-ol and retinol. Students and teachers should note that the statement ‘like dissolves like’ is not an explanation for solubility.

(iii) The majority of students correctly identified the action of hydrogen peroxide as an oxidising agent.

(c) (i) The majority of students correctly identified the aldehyde functional group.

(ii) Many students did not address the question in its entirety. The question specifically asked for chemical tests. Therefore, responses such as testing for pH, boiling points, or smelling the solutions were not given credit. The question specifically asked for three tests. Some responses suggested a process of elimination could be used to identify the solution for the third beaker, but this assumed that each beaker contained a different solution. The best responses discussed acidified dichromate eliciting an orange to green colour change for solutions that contained either an alcohol or aldehyde functional group, testing with Tollen’s reagent to positively identify an aldehyde by the formation of a silver mirror. These responses also explained that a carboxylic acid could be identified by effervescence when sodium carbonate solution was added.

Question 9

(a) Many students knew that effervescence/bubbling occurred, but very few addressed the observation that was associated with the end of the reaction.

(b) Only approximately a quarter of the students gained the mark for correct use of significant figures. Most failed to give answers to four significant figures for each of the first five calculations, or expressed the percentage yield to four significant figures.

(i) Most students correctly calculated the number of moles. A few failed to convert the volume to litres or used an incorrect formula for n = CV.

(ii) Students that were successful in (b) (i) also answered this question correctly.

(iii) (1) Poor interpretation of the question meant that many students calculated the number of moles of acid reacted at this point rather than in the next part of the question.

(2) Those students who answered the preceding question correctly usually achieved the correct answer for this question. Many of the students who had already calculated the number of moles of acid reacted in the previous question proceeded to another subtraction here.

(iv) This question was usually calculated correctly, although rounding errors were often evident. Some students attempted to use the total mass of the ore sample to represent ‘m’ in an incorrect calculation.

(v) Many students were able to calculate the percentage correctly.

(c) Few students achieved full marks for this question. Many students realised that CaCO3 would also react with HNO3, but about half of these students failed to elaborate on the consequence of this on the calculations. Some responses lacked clarity and did not distinguish well between the calculated percentage and the actual percentage of PbCO3. A few students attempted to answer the question in terms of the relative activity of Ca and Pb metals.

Question 10

(a) (i) Many students gained full marks for this question. Some failed to show any states of matter in the equation and the most common misconception was to label methane as a liquid.

(ii) This question was generally well answered, with most students gaining all marks. Most commonly, students who did not achieve full marks multiplied 890 kJ by the molar mass of methane as opposed to the number of moles in 1 g of methane.

(b) (i) Nearly all students identified the conditions as being anaerobic.

(ii) Approximately two thirds of the students were able to give a relevant advantage for obtaining methane from organic waste rather than from mining processes. Responses should relate specifically to the scenario given in the question and statements such as ‘environmentally friendly’ are too vague.

(c) (i) The majority of students gained full marks for this question. Poor reading of the question by some students resulted in the assumption that the number of moles of methanol burned was 1 mole, rather than calculating the number of moles present in 17 g of methanol as required by the question.

(ii) Nearly all students were able to state a correct reason, with the most common responses involving heat loss to the environment.

(d) A minority of students gained all marks for this question. Many students mistakenly associated the presence of O atoms in methanol with ‘cleaner’ combustion. Correct responses related the lower operating temperatures of engines powered by methanol to less energy being available to provide activation energy for N2 and O2 particles to produce nitrogen monoxide. Students and teachers are reminded that simply restating information given in the question does not attract any marks.

Question 11

(a) (i) Most students correctly identified the functional group as being an alkene.

(ii) Very few students gained full marks for this question. Many correctly identified CO2 as being non-polar, but then did not provide a clear explanation for the distribution of charge throughout the molecule. A regular misconception was that the molecule was polar as it was v-shaped. The best responses referred to the bonds being arranged so that their polarities cancel or that the vector sum of the dipoles is equal to zero.

(b) (i) The majority of students correctly identified the ester group in the lactone monomer.

(ii) About half of the students were able to draw the correct structure. The most common errors were to draw a carboxyl group rather than the carboxylate ion or to omit the hydroxyl group.

(c) (i) Most students correctly identified this reaction as an addition polymerisation.

(ii) (1) Most students gained full marks for this question. Of those who did not, the majority were able to identify that exothermic reactions produced heat but then failed to give a specific use for the heat produced. General statements that only referred to the heat being used somewhere else did not identify a specific benefit to the manufacturer and were not credited with a mark.

(2) The diagram was drawn neatly and precisely by the majority of students. However, a number of students were careless in their representations of activation energy and enthalpy and thus did not gain all possible marks.

(d) Relatively few students gained full marks for this question, because four distinct and valid points were required. Most students made the connection between the use of CO2 in the new manufacturing process and the associated reduction in global warming. However, a failure to articulate specific environmental benefits limited them from gaining further marks. A common misconception was that lower atmospheric CO2 levels limited environmental damage due to acid rain.

Question 12

(a) (i) Most students were able to determine a correct value for absorbance from the graph. However, many had difficulty in applying the resolution to define a range. A few students incorrectly interpreted the question to give the range of values that would be a fair estimate of the absorbance.

(ii) (1) Most students were able to name a volumetric flask. Common mistakes included burette and conical flask, as used in titrations.

(2) Approximately half of the students gained both marks. It was common for students to give an unclear explanation of the link between the wavelength emitted by the silver cathode lamp and wavelengths absorbed by the silver ions.

(iii) The majority of students gained the mark. Several students simply stated ‘scatter’ without reference to the line of best fit and so were not awarded the mark.

(iv) Only a small number of students gained this mark, because most failed to realise that the line of best fit could have passed through the origin due to the resolution of the spectrometer.

(v) Many students gained both marks. The most common error was an incorrect conversion of ppm to mg L-1.

(b) The majority of students correctly identified H2O as the first product and many were able to draw the correct structure for the organic product. The most common errors in the organic product were leaving two hydrogen atoms on the nitrogen and not removing the positive charge.

## Operational Advice

School assessment tasks are set and marked by teachers. Teachers’ assessment decisions are reviewed by moderators. Teacher grades/marks should be evident on all student school assessment work.

Most classes completed the Variations — Moderation Materials form appropriately when required. Moderators did note the occasional inclusion of this information on the learning and assessment plan (LAP) addendum instead. In some instances these details were missing, making it quite difficult to determine the impact on the evidence provided.

Moderators noted occasional examples of grades for individual students or entire classes allocated to incorrect assessment types. Teachers should take care when entering grades in *Schools Online*.

Chemistry

Chief Assessor