Chemistry

2012 Chief Assessor's Report

Government
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SACE
Board of SA

CHEMISTRY

2012 CHIEF ASSESSOR'S REPORT

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

This year, moderators noted an improved use of performance standards in the assessment of student work, generally leading to closer alignment between student evidence and the assigned grade level. It was occasionally difficult to confirm a teacher's decision as there was no indication of how grades had been assigned; no assessment rubric was included, and student work was not annotated. A diversity of standards was sometimes noted in the folios assessed at a particular grade level within the one assessment group. This was particularly noticed at the A+ grade level. Moderators emphasised the need for sharing of assessment tasks and the grading of student work, for an internal moderation within an assessment group, when classes taught by different teachers are combined into a single group. In this situation, differences in marking and overall assessment of grade levels may disadvantage some students. Teachers are advised that in the moderation process all students in a grade level are dealt with in the same way; either all students' grade levels are retained or all are adjusted. Teachers are reminded that an A+ should only be assigned when the evidence in a student's folio demonstrates sustained achievement at the upper level of the A grade band as described in the performance standards.

Where folios are incomplete, the details are to be noted on the Variations — Moderation Materials form.

Teachers who participate in the moderation panel gain insights into the design and assessment of tasks that they can then implement in their own practice, which is of great ultimate benefit to their students. Teachers are strongly encouraged to participate in this important process.

Assessment Type 1: Investigations Folio

Practical Investigations

Although some improvement was noted, a number of teachers continue to use rubrics and marks schemes that do not align with the assessment design criteria, the specific features, or the performance standards. This frequently included generous weighting of manipulative skills compared with investigation, analysis, and evaluation skills, and resulted in poor correlation between the grade level based on marks, and the grade level based on the performance standards. Generally, teachers who made explicit use of performance standards tended to be more successful in the assessment of student evidence.

Adjustments downwards during moderation generally resulted from lack of evidence at the appropriate standard in analysis and evaluation skills. Frequently this was due to the setting of tasks in which heavy scaffolding, closed questions, and limited space restricted opportunities for students to achieve at the higher levels. Student evidence aligned most closely with the assigned grade level when the task instructed students to *discuss*, *explain* and *evaluate* procedures and results, rather than to *state* or *identify* a defined number of points. Allocation of a fixed number of marks was also found to limit student responses.

Error analysis in practical investigations continues to be problematic. Confusion of random and systematic errors, and their relationship to precision and accuracy, was evident amongst many students. Of equal concern was the general nature of the discussion of errors. The same terms were often defined in great detail in more than one task, and examples described were vague and generic, rather than explicitly referring to the practical undertaken. General statements relating to contamination of solutions, poor calibration of instruments, and errors of parallax in readings figured repeatedly in many practical reports. Some excellent student work discussed errors in the context of the particular practical, and related specific errors to specific aspects of the procedure. Few students were able to critically and perceptively discuss the relative impact of these errors on results and on the final conclusion.

Teachers are reminded that assessment of particular specific features is not required in every task. For example, discussion of errors, accuracy, and precision is not appropriate in an organic preparation, but is more appropriate as a key aspect of the design investigation.

Moderators noted a limited range of design tasks this year and encourage teachers to have confidence in trying new tasks. It is important in these tasks for students to show evidence of how they designed the task, rather than merely varying a practical provided by the teacher. Such evidence could include specification of quantities required for the preparation and dilution of an original solution to prepare the series of solutions used, and an explanation of how this set of concentrations was determined as being suitable for the investigation. An explanation of why and how certain factors are held constant would also indicate competence in design skills.

A strong focus on hazard assessment and increased awareness of safe laboratory practices compared with previous years was noticed, and welcomed.

Teachers are reminded that evidence should be provided for grade decisions made relating to specific features I3 and A3. An example of such evidence can be found in the support materials on the SACE Board website.

Issues Investigation

Traditional research reports, incorporating an information search and evaluation, proved to be the most common format for the issues investigation, although investigations comprising a number of different tasks were not uncommon. Of considerable concern was the number of students who did not, as specified in the subject outline, formulate their own question to research, but chose from a list provided by their teacher. Of those investigations based on a question, a large proportion of questions related simply to a *topic* rather than to an *issue*, and sometimes to a topic with little chemical basis. Conclusions often did not relate at all to the original question. Teachers are encouraged to provide students with the guidance needed to formulate a question in which they inquire into an issue of social or environmental relevance to chemistry. An inappropriate question reflects poor investigation design, and limits the opportunities for a student to discuss logically and perceptively the chemical background of the issue, to identify alternative views, to explain the different perspectives of the issue, or to arrive at relevant conclusions.

While some improvement was evident this year in the use of in-text and footnote referencing, a number of investigations contained minimal or no referencing. Some investigations with very few sources cited in the body of the report, had extensive bibliographies and reference lists, often some pages in length. The subject outline specifies that a completed issues investigation should include citations and a list of references; that is a list of all publications referred to in the work. Such a list should not include publications that are not specifically referred to in the text.

Evaluation of sources generally used a familiar provided format, assisting students to address key criteria in an organised manner. Moderators noted that statements relating to bias and credibility were often not substantiated by evidence consistent with achievement at a high level in this aspect of the investigation. There were also many instances of three, even four, information evaluations. In such cases, the evaluations were often very similar in content, adding little to the evidence of student performance, but adding to the word-count. A few investigations exceeded the word-limit, with no indication that this had been noted and acted upon by the teacher. In a few of these cases, the word-limit was not explicitly stated in advice to students.

Assessment Type 2: Skills and Applications Tasks

Adjustments in this assessment type during moderation were less common than for Assessment Type 1. Although not a requirement of the subject outline, tasks in this folio were almost exclusively in the form of tests assessed by marks. It was pleasing to note the creativity shown by some teachers who had developed alternative tasks, such as multimedia or oral presentations.

Within the folios a wide variety in range and allocated time was noted. It was noted that some folios did not address the full content of the subject outline. Some tasks limited the opportunity for students to demonstrate achievement over the range of grades in the performance standards. In order to provide such opportunities, tasks should incorporate some recall and simple, scaffolded applications, but must also include open-ended, unfamiliar, and unscaffolded complex problems that allow students to demonstrate deep and broad knowledge and understanding, high-level problem-solving skills, and critical and perceptive analysis and evaluation of information and procedures. If questions from past examination papers are used, it is essential to select questions that demonstrate a range of content and complexity.

A number of teachers continue to convert an overall mark percentage directly into a grade. While this is valid with well-designed tasks, such practice with poorly designed tasks results in poor correlation of the grade level assigned with the performance standards.

EXTERNAL ASSESSMENT

Assessment Type 3: Examination

General Observations

The mean percentage and range of question means for the examination were similar to those of last year. Questions 3, 6, and 9 were the most difficult for students, while Questions 1, 2, and 7 were the easiest.

Answers written on the blank page at the end of a booklet must be clearly identified, and in the appropriate booklet.

Students are reminded to write legibly, and clearly make any required corrections.

Poor reading of the questions continues to be a problem for a number of students. For example, in response to Question 10(c)(iii), many students discussed the effect of high *pressure* when the question mentioned *temperature*. Similarly, in Question 11(d)(i), many circled polar bonds rather than showing their polarity. Some students might benefit from highlighting key words in the questions. Other students miscopied formulae given, such as Fe_3O_4.

The number of marks and the space allocated for each question are provided to assist students in preparing an appropriate answer. Some answers were too brief for the marks allocated, while others were far too wordy for the marks allocated. The marks allocated indicate the number of points sought in the answer. Answers that exceed the space provided should be the exception.

The subject outline specifies that students are expected to develop and demonstrate an ability to communicate in a variety of forms, using appropriate chemical terms and conventions. However, students' written expression was often poor. Not only was sentence construction poor, but mastery of the language of chemistry — terms, expressions, and conventions — was disappointing, with words and terms used interchangeably or incorrectly. Some, for example, referred to yeast as a catalyst, while others wrote as though 'ammonium' and 'ammonia' are the same. Students confused ions with compounds and atoms, and used the terms 'atoms' and 'molecules' as though they are interchangeable. Others confused 'frequency' and 'wavelength' in Question 3(a)(iv) on atomic absorption spectroscopy, or gave an ion when a compound was asked for. Many common chemical terms were misspelt, such as 'keytone' instead of 'ketone', and 'flourine' instead of 'fluorine'. Conventions were unknown or unacknowledged by a significant number of students. For instance, 'pH' was often written as 'PH' or 'Ph', and the delta sign was often written poorly, often looking like other symbols (commonly 'S', 'd', 'σ', or 'α', rather than 'δ'). Students who use acronyms or other abbreviations are advised to define them in each question booklet of the examination.

Many student responses could be improved with a little thought before an answer is written. Restatement of information in a question (e.g. Question 5(b)(v)(2)) is not given any credit, nor is restatement of the same point as both the introduction and conclusion to a response. Students need to be aware that they are not awarded marks if they make two attempts at a question and one is incorrect. Students are encouraged to read through their answers, particularly those in response to 'explain' questions; such action may help eliminate false statements, as well as statements which may be confusing, ambiguous, or contradictory. Checking through chemical equations should be expected in all cases.

In calculations the use of significant figures continues to be problematic. Some students appear to not understand that the number of significant figures is not the same thing as the number of decimal places. Many students did not recognise that the appropriate number of significant figures is determined by the number of significant figures in the least precise data supplied. In their calculations, a number of students appeared to transfer data incorrectly from calculator to page or page to calculator. On the other hand, the inclusion of units in measurements was pleasing to see. In many cases students could benefit from improved setting-out of calculations. A wrong answer may be able to gain marks if markers are able to discern where errors have been made.

Poorly drawn structural formulae were prevalent in some questions (e.g. Question 7(c)(i)) with some diagrams showing the H of the hydroxyl group bonded to the hydrocarbon chain. Students are advised to remember that C is tetravalent and O is divalent, and to count the number of bonds on each atom every time they are asked to draw a structural formula.

Some students do not recognise the difference between a half-equation and a full chemical equation, with electrons being omitted from a half-equation. Many students showed an inability to use conventions in graphs, being unable to correctly draw a line of best fit (Question 4(a)), with many joining the dots.

Use of the word 'bonds' to represent secondary *interactions* continues to be a problem. Students either have no distinction in their minds between primary and secondary forces, or cannot articulate the difference. Students lost marks for statements such as 'diesel has a higher boiling point as it has larger molecules so *its bonds are difficult to break*', failing to identify which bonds were difficult to break. Such an expression can be read as 'covalent or intramolecular bonds are difficult to break', bonds which have no influence on the boiling point of a molecular substance. Likewise, students frequently did not demonstrate an appreciation that bond polarity and molecular polarity are different concepts with different rationales. The term 'ion–dipole bonding' was used interchangeably with 'hydrogen bonding' or 'dipole–dipole interaction' by many students.

Environmental chemistry appears to be confusing for some students: ozone is given as the cause the greenhouse effect, and acid-rain formation is confused with nitrogen fixation.

Question 1

(a) (i) Well done, with almost all students gaining full marks. A small number gave NO_2 as the answer.

(ii) Many students divided by 1000. Some students left the answer as 0.029×10^3. The most common incorrect answers were 0.029 and 0.0000029. A few students appear to have misread the table and wrote 28 ppb (i.e. Location B).

(iii) Generally well done. Some students failed to differentiate between NO_2 and SO_2 in their contribution to photochemical smog, while several students mentioned both. Some students used the total amount of pollutants to reach their conclusion and were penalised. Some students gave the answer as Location A due to its higher ozone level, failing to note the effect of NO_2 on ozone formation. A small number mentioned CO as being a determining factor in selecting Location A.

(iv) (1) This was done very well, with most students gaining full marks. Most students were able to include the correct equations in their answer. Some students began by unnecessarily describing the formation of NO_2, while others combined both processes into one. A small number of students failed to mention sunlight or the photochemical nature of the process. High temperature was occasionally mentioned instead of sunlight.

(2) This was poorly done, with global warming and the greenhouse effect being the most common answers and acid rain being mentioned occasionally. Photochemical smog was mentioned by a small number of students. Some linked ozone to an environmental issue such as photochemical smog, rather than describing an *effect* of its presence.

(b) Most students were able to gain at least 2 marks for this question. Incorrect responses included the use of incorrect formulae (e.g. H_2NO_3) or describing the conversion of NO_2 going to NO_3. Some students began with N_2 as the starting point, referring to nitrogen fixation and nitrogen-fixing bacteria. Some students were unable to differentiate between ionisation and dissociation. A small number failed to gain full marks by not reading the question carefully and failed to mention the ionisation of HNO_3 to form nitrate ions or the nitrate ions entering the soil.

(c) (i) Well done, although some students showed the charge on one functional group, but failed to add a proton to the amino group. A few students omitted the CH_3 group. Students who drew the protonated amine as an extended-structure amine and wrote the positive charge on one of the H atoms rather than the N were penalised.

(ii) Well done, with 'amine' and 'polypeptide' the most common incorrect answers.

(iii) Well done, with NO_3^- or NO_2 and ammonium as the most common incorrect responses. A significant number of students wrote 'ammonia' then added an incorrect formula, usually NH_4 or NH_4^+. Students should be aware that penalties are applied when contradictory answers are given. The writing of ions in response to a question that asked for a compound suggests a lack of understanding of terminology.

Question 2

(a) (i) The majority of students had the correct answer, with both 'primary' and 'tertiary' given on occasion.

(ii) (1) This was generally well done, although some responses suggested students were unfamiliar with structural formulae that do not show all of the carbon and hydrogen atoms. Some students stated that fructose was a polyhydroxy ketone or aldehyde without specifying which. Students should be aware that answers should relate to the information provided in a question. Some students wrote fructose was a carbohydrate because it contained C, H, and O, or because it had a large number of polar hydroxyl groups, neither of which gained marks. Reference to the general formula $C_xH_{2y}O_y$ was given by many students who did not relate this to the structural formula given. Some students who said that fructose contained a ketone (often spelt 'keytone') functional group failed to mention the multiple hydroxyl groups. Solubility of the compound was occasionally discussed.

(2) Students who had correctly described fructose as a polyhydroxy ketone almost invariably had the correct answer, although the answer was not always consistent with the previous answer. However, many failed to focus on an *observation* and stated 'nothing happened'. A surprising number of students referred to a secondary alcohol being oxidised by

Tollens' reagent. Some students related reaction with Tollens' reagent to aldehydes, but could not relate that to the fact the fructose contains a ketone functional group and is not an aldehyde. It appeared that some students had not read the question carefully; they wrote about the positive result for a test with Tollens' reagent, without thinking about whether this would happen.

(b) (i) Most students correctly identified A as a hydrogen bond. However, B was poorly identified, with many suggesting dispersion forces, dipole–dipole bonds, sulfide bonds, or crosslink. A small number of students interchanged the answers. Some students who correctly identified B as a disulfide link described it as a dipole–dipole interaction.

(ii) Well done. Most could correctly identify the stronger bond.

(iii) Although most students recognised the relationship between shape and structure, most students were unable to explain why the shape changed. Too many used poor descriptive language to suggest why pH has an effect on enzymes. Some wrote of breaking the bonds (rather than the secondary interactions) of the enzyme or wrote long dissertations on the collective effects on a range of functional groups. Use of the term 'denatured' was prevalent, often without mentioning why the shape was changing. Ionic bonds were frequently mentioned. A significant number of students appeared to have attempted to rote-learn a description without understanding how a change in pH affects an enzyme.

(c) (i) Mainly well done. Some incorrectly wrote the equation for photosynthesis, while others wrote the fermentation equation. A small number of students did not balance the equation. Students who had 'energy' written on the arrow as a condition were penalised.

(ii) This was poorly done; many students failed to include the negative sign, even though they had correctly calculated the value. In other cases, the wrong value was given, often with the correct negative sign.

Question 3

(a) (i) Very few students were able to gain the mark for this question, with many citing contamination as a possible random error. Systematic and random errors refer to unavoidable problems that are associated with making measurements. Mistakes made by an experimenter, whether in reading instruments, recording measurements or in the calculations, are not considered in analysis of errors. It is assumed that the experimenters are careful and competent. Thus no credit was given for answers such as: 'incorrect mass put into the solution', 'failure to correctly rinse the equipment', 'incorrect measurement made', 'incorrect concentration of the solution', 'not filling to the graduation line', and 'meniscus not on calibration line'.

A number of students referred to a measuring cylinder being used in the preparation of an analytic solution. Many answers were generic and did not refer to the situation described in the question. While a small number of students gained the mark for identifying parallax error, the best answers referred to the fluctuations in eye level when reading the meniscus.

(ii) Well done. Most students identified absorbance but some identified the concentration of Na^+.

(iii) While the obvious answer was 'systematic error', the allocation of 2 marks for the question guided most students to recognise that some elaboration was required. When students offered an explanation or example, it was usually well done. Several students referred to contaminants with extra sodium in reference to the 0% solution only, failing to appreciate that it would be present in all prepared solutions. Contamination by sodium in the air was mentioned quite often. Some answers referred to procedural mistakes, again demonstrating a lack of understanding of errors. Random error was referred to occasionally. Full marks were not given when students described the fact that the graph did not pass through the origin without suggesting a source of error.

(iv) Very few students gained full marks because very few mentioned electrons or electron configuration in their answer. Some merely stated that the atomic absorption spectroscope was set up for sodium, providing no elaboration of what this meant. While others mentioned that the sodium absorbed a specific wavelength, no reference was made to calcium nor why it did not absorb that wavelength. Some answers described the spectroscope as absorbing sodium ions rather than the sodium ions absorbing wavelengths of light; similarly, some students had the spectroscope absorbing sodium ions but not calcium ions. Some students referred to the sodium lamp without reference to the specific wavelengths of light. Several students confused wavelength and frequency and others appeared to be unaware of the relationship between frequency and wavelength, making comments that the detector could only absorb wavelengths of specific frequency.

(v) Responses showed very poor reading of the graph provided, with many incorrect absorbance values given. It is recommended that students use a ruler to assist in this process. Many students with a correct reading of the graph, failed to attempt the second part, and many who did divided by 20 (the dilution factor) instead of multiplying.

(b) (i) While most students answered this correctly, there was inconsistency in answering this question. It appeared that some students did not understand the terms 'spontaneous' and 'non-spontaneous'.

(ii) Approximately half of the students correctly identified B.

(iii) (1) Well done. The most common errors involved placing the electrons on the wrong side of the equation or failing to balance the equation. A few students started with OH^-, and a small number had H_2 rather than H^+ ions being produced.

(2) This was reasonably well done, although many students reduced sodium instead of sodium ions. Many answers confused oxidation with reduction, mentioning, for example, sodium metal being reduced, or sodium ions or water being oxidised. Students wrote of water being reduced to form oxygen, and sodium being more reactive than water. Cl^- was occasionally oxidised in preference to sodium. The electronegativity of sodium and chlorine were also mentioned in this question. Some made reference to the need for NaCl to be in molten state, but could not explain why this was necessary.

Question 4

(a) Most students gained at least 2 marks. Marks were deducted for selection of scales that made plotting points too difficult, poor plotting, continuing the x-axis beyond 100%, extending the line of best fit beyond 100%, drawing a straight line of best fit, or drawing a line of best fit that included all of the plotted points. A large number of students appear to not understand the concept of line of best fit; joining of the plotted points was the most common line drawn. There was also a significant number who believed that a straight line was required for the line of best fit. Some students who realised that a broken scale was appropriate did not indicate the break in the vertical axis.

(b) Well done. If marks were lost, it was usually for failure to divide by 2, failure to multiply by 1000, or failure to calculate moles of ethanol. Some students had difficulty in calculating the number of moles correctly because they had the molar mass incorrect. Many students could not correctly rearrange the formula. In a small number of cases, the mass of ethanol was used instead of the mass of water. Some answers were poorly set out.

(c) While this question asked students to recall information, very few were able to gain full marks. However, those students who recalled some of the information were able gain reasonable marks. Most students could correctly write the equation for fermentation and most knew of the need for yeast and warmth. Confusion came when students attempted to write about 'winemaking' or 'how we did it in the lab' rather than answering the question. Some students believed yeast to be an enzyme rather than a living organism. Many appeared to lack the understanding that cellular respiration (both aerobic and anaerobic) are biological processes requiring living organisms. Some students knew that the reaction needed acidic conditions but failed to specify a pH range or use the term 'slightly acidic'. Similarly, they were imprecise with 'heat', failing to give a temperature range.

Common errors included statements that reflux was necessary, apparently confusing fermentation with an organic preparation carried out during the year.

The allocation of marks for the effective communication of knowledge and understanding of chemistry considers such factors as spelling, grammar, logical sequence of the answer, and the presence of irrelevant information. Examples of irrelevant information included the effect of temperature on reaction rate, a description of the denaturation of the enzyme, describing how fermentation was done in class, lactic acid production, and the hydrolysis process whereby glucose is formed from the polysaccharide.

Question 5

(a) Well done. Some of the more common incorrect answers stated that Ta has a low electronegativity, that it can exist as anions, or that it is not stable. Some students suggested that tantalum's reactivity was related to its being a transition metal.

(b) (i) Most students were able to make the connection between surface area and an increased rate of reaction, although some did not explain the importance of an increase in surface area. A few students tried to discuss the froth flotation process. A significant number proposed that crushing would increase the concentration of mineral (or of metallic Ta) in the material.

(ii) Not well answered. A surprising number wrote Fe or Mn salts, without attempting to write a formula.

(iii) (1) Balancing was generally excellent; a few doubled the coefficients. Very few made no attempt at all.

(2) Many students included excellent diagrams with the partial charges and hydrogen bonds correctly labelled. A small minority reversed the partial charges. A significant number of students drew the structural formula of water with double bonds between the oxygen and hydrogen atoms, or with two O atoms bonded to a central H atom. Unfortunately, the descriptions were frequently more appropriate for dipole–dipole interaction rather than the specific instance of hydrogen bonding. The best answers mentioned that hydrogen bonding is only possible when a small highly electronegative atom is covalently bonded to the hydrogen atom and that the resulting intermolecular attraction is a particularly strong form of secondary interaction.

(iv) This was very poorly done, suggesting that interpretation of the flow chart proved difficult for most students. A number of students wrote ions such as hydroxide, rather than a reagent, which was specifically asked for in the question. Sulfuric acid and HF were popular incorrect choices.

(v) (1) This was very well done, although some used upper-case letters or failed to use superscripts. A few wrote the electronic configuration for the ion (often incorrectly).

(2) Most students knew that Al was more reactive than Ta, but few went on to explain logically its relationship to the tantalum ions. Most simply repeated information already given in the question; that is, that Al reduced the Ta ion. A number of students appear to have not read the given information carefully and mistook it as describing an electrolytic cell, bringing the presence or absence of water into their answers. Alternatively, they may have been more familiar with applications of relative reactivities within the context of an electrolytic cell and were unable to formulate an appropriate response in another context.

Question 6

(a) Very poorly done, with most students failing to gain any marks. Often students included '-ane' (or '-an-') in the name, apparently unaware that this suffix is only used in the absence of double or triple carbon–carbon bonds. The use of commas and hyphens in organic nomenclature is not well understood. The numbering of the carbon chain was often incorrect. Many referred to the compound as a 'pentene' or 'propene', while quite a few did not recognise it as a 'diene'.

(b) (i) Well done, although some had the formula inverted. It was reasonably common for M to be calculated incorrectly.

(ii) This was poorly done, with all values between 0 and 6 being encountered, a minority giving the correct answer of 2. Consequently, it would appear that the majority of students are unaware that zeros are only significant on the end after a decimal point or between other significant figures.

(c) The responses to parts (i) and (ii) were generally poor with many being confused and/or speculative. References to cheaper/easier/more convenient/less polluting/lasts longer were made with respect to both natural and synthetic rubbers, but claims were rarely substantiated by any logical reasoning.

(i) Many responses focused on such advantages as 'its manufacture emits less pollutants', 'doesn't run out', or 'lasts longer'. The description often reworded the advantage without adding further information.

(ii) A number of students wrote some well-considered responses here and gave perfectly reasonable answers. On the other hand, a very large number used information in part (e) to formulate their responses. They referred to improved properties compared with natural rubber, rather than on the possibility of making a range of synthetic rubbers from a range of monomers. Although synthetic rubber can be modified, making possible a wider variety of applications, natural rubber can also be modified. A few well-reasoned responses discussed the use of land for agricultural purposes, rather than for rubber production.

(d) Well done.

(e) (i) Most responses gained 1 or 2 of the possible 3 marks. The best responses discussed how the strong covalent bonding between the chains prevented the polymer chains from slipping over each other, leading to greater strength, greater hardness, and charring (rather than softening) when heated. Many responses referred to the increased strength in secondary interactions between the chains and were clearly unaware that cross-linking is primary bonding. Most students failed to mention that extensive cross-linking prevented the chains from sliding past each other. Some responses gave a catalogue of changed properties without explaining how vulcanisation leads to these properties.

(ii) Few responses mentioned that vulcanised rubber could not be reshaped or remoulded. Often, answers implied that, with enough energy, reshaping was possible, overlooking the charring that would take place.

Question 7

(a) Mostly well done. Some students wrote on the skeleton to assist their addition.

(b) Mostly well done. A small number thought there would be a colour change from brown to colourless, possible in the belief that Br_2 would react with any double bond. A number of students used the word 'clear' instead of 'colourless'.

(c) (i) Mostly well done, although a surprising number of students unnecessarily expanded the skeletal structure. This provided no advantage and sometimes led to an error. As in previous years, there were a significant number of poorly drawn bonds. The number of OH—C bonds was also of concern.

(ii) Mostly done well. A small, but significant, number of students mistakenly wrote that Tollens' reagent reacts with alcohols. Some students who correctly identified the need for dichromate ions omitted to mention that the solution needs to be acidified.

(d) (i) Most students obtained at least 1 mark here. While many students recognised the hydrocarbon chain as being non-polar, their answers implied it, rather than stated it. Similarly, many did not specifically state that the ketone groups were polar. Some referred to the ketones as carboxyl groups, and others did not recognise the presence of an ester functional group, referring to it as a second ketone group with the other oxygen being a third functional group. As in Question 2(a)(ii)(1), a significant number of students referred to presence of 'keytone' functional groups. Many responses referred, incorrectly, to the presence of a benzene ring.

(ii) Students have shown in the past that they are able to do well in this type of question; this was demonstrated again with almost all gaining at least 1 mark and often 3. There was commonly a lack of reference to the slower movement of Compound C through the column/coil. A number of responses referred to movement of the mixture through the chromatogram, as though the components moved together. A significant number of students confused the question with thin-layer chromatography, referring to the smaller distance moved, rather than the longer time taken, due to the stronger attraction to the stationary phase. Some contradictions occurred when students had answered part (d)(i) by correctly explaining why Compound C was more polar than chiloglottone-1 but then stated it to be non-polar in this answer. A number of students who had incorrectly answered part (d)(i) were able to logically work their way through this part and were given credit. It was pleasing to note that almost all students referred to 'adsorption'; 'absorption' was very rarely used.

(e) (i) (1) Well done, with 'isotopes' the most common incorrect response.

(2) Very well done.

(ii) Mostly well done. In spite of the given example, many students failed to use hyphens and commas correctly. A small number of students reversed the numbers of the carbon atoms to which the alkyl groups were attached.

Question 8

(a) (i) While some students demonstrated some creativity, most correctly stated water or H_2O.

(ii) Well done, with the most common mistake being to identify the reaction as addition polymerisation.

(iii) Good work; most students knew that magic sand and oil were both non-polar. A few argued one to be polar and the other non-polar, and hence they attracted each other.

(iv) Many believed the question involved oil as in part (a)(iii). Of the small number who referred to micelles, few were able to do so successfully. Common errors included answers which were written in terms of triglycerides, suggesting that these students were comfortable with detergents acting in the familiar context of removing oils/greases, but could not make the connection to the unfamiliar context. Another reasonably common error was to describe the reaction of the detergent with the sand.

(b) Very few students were able to achieve full marks here, but most students attempted the question and many were able to achieve more than half-marks. The best responses included discussion of the reversibility of cation exchange, Le Châtelier's principle, and the need for concentrated NaCl solution for the recharging process. Generally, the majority gained more marks in discussing the softening action than the recharge. Some wrote of chloride ions being exchanged (and, rarely, OH^-). A few neglected to state what hard water was. Some wrote equations or explanations that showed a redox reaction at the zeolite surface. It would appear that these students understood 'displacement' to mean redox displacement, and their responses commonly referred to the relative reactivities of Na, Mg, or their ions. Confusion of the process with flocculation was not uncommon, with a significant number of students believing that the zeolite particle and the Ca^{2+} ions formed large clumps which precipitated from the water. A significant number of students believe that Ca, Mg, and so on are heavy metals, and that Al, Mn, Cu, Pb, and Hg ions contribute to water hardness. A few students used diagrams to illustrate the process. While many of these were excellent, teachers should remind students that any diagram should be clear, relevant, and appropriately labelled.

Question 9

(a) (i) Poorly done. Although the decomposition of hydrogen peroxide is mentioned in the subject outline, more than half of the students wrote hydrogen and oxygen gases as the products, possibly because it simplified the balancing of the equation.

(ii) It was uncommon for students to score full marks here. Although the concept of increased temperature providing additional energy to molecules was well known, students often failed to mention frequency or 'per unit time' with regards to increased number of successful collisions, and/or failed to refer to activation energy. Students frequently referred to the particles 'overcoming' activation energy, rather than particles having energy in excess of the activation energy.

(b) (i) Rarely did students convert 6.0% to 60 g L^{-1} correctly. Students were awarded a mark for correctly calculating the molar mass of sodium hypochlorite. However, many students subsequently multiplied, rather than divided, by this molar mass.

(ii) This half-equation was quite well done. Some students wrote Cl_2 as the product rather than chloride ions. Some wrote electrons on the incorrect side or not at all. Some had incorrect formulae (e.g. HClO or $HClO^-$) or omitted charges from ions. Some students were able to write this half-equation correctly in alkaline conditions even though this is not required in the subject outline.

(c) (i) Well answered.

(ii) A majority of students received full marks for their explanations. Those who did not often failed to recognise that the acidic products of the equilibrium would react with the hydroxide ions in the solution. A common mistake was to state that Cl_2 was acidic and would be neutralised by OH^- present at the high pH, with the consequence that the smell would not be evident.

(iii) A surprisingly large number of students failed to recognise that pH calculations involve hydrogen ions, whereas the question asks for the concentration of hydroxide ions. Thus they failed to employ either of the relationships pH + pOH = 14 or $[H^+]\,[OH^-] = 10^{-14}$.

Question 10

(a) (i) The most common answer was 'photochemical'. Other answers which were given credit included 'photolysis' or 'photosynthesis'.

(ii) Many students incorrectly wrote the oxygen molecule (O_2) as a product, rather than 'atomic oxygen' as specified in the question.

(b) Generally well done, with failure to balance correctly or to copy a formula correctly being common errors.

(c) (i) Many students failed to mention the gaseous state in their answers. Pressure change only affects the position of an equilibrium if there are a different total number of moles of gas on the two sides of the equation. Some students did not refer to the stress placed on the equilibrium and the response that would counteract this stress (i.e. Le Châtelier's principle). Many students referred to increased reaction rate rather than yield. Students commonly referred to the increase in concentration of reactants brought about by the increased pressure, apparently failing to realise that an increase in pressure will increase the concentrations of all species — reactants and products. Many students needlessly discussed a change in volume, apparently not appreciating that this is not the only means by which pressure may be increased.

(ii) Well done. The most common answers referred to cost, and the danger associated with the use of high pressure. A small number noted that, with a high yield of 96%, the improvement in yield associated with a higher pressure was not worth the associated cost.

(iii) Many students wrote answers of a high standard but had difficulty with the concept of 'compromise'. They had trouble with discussing the effects on yield and rate of temperatures above and below 450°C. Many did not mention the exothermic nature of the forward reaction in discussing the effect on yield. Students commonly incorrectly described 450°C as a high temperature rather than a compromise temperature.

(iv) Students should be alerted to the fact that they are not awarded marks for repeating information given in the question. Many students failed to identify that lowering the overall activation energy would increase the rate of reaction. Others incorrectly described the catalyst as 'not being used' or 'not taking part' in the reaction, when clearly it is involved. A pleasing number of students preferred the description 'the catalyst can be recovered when the reaction is completed'.

Question 11

(a) A disappointingly large number of students identified p-block, but wrote an upper-case P or a letter which could not be distinguished as being lower case. Students should be aware that an ambiguous answer is treated as incorrect.

(b) Students who referred to molecules and molecular polarity here showed their lack of understanding of the difference between bond polarity and molecular polarity. Many students failed to mention the identical electronegativity of the two carbon atoms and the consequent equal sharing of electrons.

(c) (i) (1) Poorly drawn. While many students correctly drew a PO_4 structure in a tetrahedral arrangement, rarely did students allocate the three negative charges or the bonds appropriately.

(2) Fairly well done. Some students omitted the positive sign.

(ii) Most students recognised that hydrolysis of the ester groups would produce carboxylic acids, but not many recognised that the alkaline conditions would generate a carboxylate anion rather than a carboxyl group. A small number of students drew an incorrect number of carbon atoms in the chain or omitted hydrogen atoms if they drew a full structure.

(d) (i) Generally well done although, as mentioned earlier, the ability to write an acceptable delta symbol ('δ') is an expected part of the ability to communicate chemical knowledge.

(ii) Not always a well-expressed answer. Students should have been referring to the many polar bonds introduced by the polymer unit, and that these polar bonds would be possible sites for hydrogen bonding with polar water. Students should realise that the statement 'polar dissolves polar' is a generalisation, not an explanation. Some students used the term 'ion–dipole interaction' which was not applicable in this question. Some students referred only to the polarity introduced by the carboxyl group at the end of the chain.

(iii) This was poorly done. Nomenclature rules are straightforward, yet there were many permutations recorded here. Examples of errors included use of '-dioc', '-doic' or '-dicarboxylic' instead of '-dioic'. Some students misplaced the 'di', and named the compound as 'dibutanoic' acid instead of 'butandioic' acid; the 'di' identifies the presence of two carboxyl groups, not two butyl chains. Stems that identified the wrong number of carbon atoms (e.g. 'prop' and 'hex') were common. Some students who did not recognise the carboxyl groups named the compound with various combinations of 'diol' and 'dione'.

(iv) Many students were penalised for failing to include the bracket and 'n' present in the monomer. Clearly, students did not understand that this is part of the monomer structure, rather than being involved in the polymerisation.

Question 12

(a) The best answers here referred to the lack of polarity of hydrocarbons and hence strength of secondary interaction occurring being influenced by molecular size (molar mass) only. Good answers referred to the greater strength of secondary forces between larger molecules, with the consequence that such molecules require more energy to be separated from each other. Better answers commonly referred to the secondary interactions as dispersion forces. Weaker answers recognised the difference in the molecular size, but then stated that the bonds in larger molecules are stronger and need more heat to break apart, suggesting that boiling is a chemical change.

(b) (i) The best answers here referred to the bent hydrocarbon chains in the unsaturated molecules and linked this to their inability to align as neatly as the saturated molecules. The better answers continued to link this closer stacking with increased strength of secondary interaction, ultimately requiring more heat to separate the molecules. Weaker answers implied that double bonds are weaker than single bonds, and failed to recognise that it is the strength of secondary forces that influences the melting point of molecular substances, not primary bonds. Some students incorrectly argued that the unsaturated molecule has two less hydrogen atoms, so its molar mass would be less and hence dispersion forces would be weaker, when a difference of two hydrogen atoms in such large molecules would have little effect.

(ii) (1) Quite well done. There were a few errors in manipulation of mL and g, but many students completed this calculation correctly.

(2) (A) Quite well done, although a number of students suggested a burette rather than a volumetric pipette.

(B) Many students failed to convert 4.2 mL correctly to litres, while some did not use this titre value anywhere in their calculations, using instead the entire number of moles calculated in part (b)(ii)(1). Many students failed to note that 20.00 mL of the diluted biodiesel was used in each titration. Consequently, the final answer was 50 times the correct value. Students accustomed to tackling stoichiometric problems using the formula $C_1V_1 = C_2V_2$ struggled. Most students failed to gain the mark for the correct use of significant figures, not realising that the appropriate number of significant figures differed in the two parts.

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