NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Scholarship, 2005

Chemistry
93102

National Statistics

Assessment Report

Chemistry, Scholarship, 2005
93102

National Statistics

No. Scholarship Results	**Results**			
	Outstanding Scholarship		**Scholarship**	
	No. Awards	% of L3 Cohort	No. Awards	% of L3 Cohort
198	26	0.4%	172	2.5%

Commentary

The 2005 examination provided 13 opportunities for candidates to achieve at scholarship level (six marks). In eight of these they could demonstrate outstanding performance (eight marks). The questions were designed so that those with the same mark should have taken a similar time to complete. Suggested times were given on the front cover. This should have given candidates a guide as to how much writing they should do for each question. The examination was successful in differentiating between the candidates who showed an exceptionally high level of performance.
It was not surprising that many candidates did not have time to finish the examination when they wrote up to four pages to answer a question designed to be answered in 12 minutes. These candidates often failed to gain many marks as their answers tended to lack the required depth, were repetitive or used circular reasoning, or had errors/gaps in their understanding of chemical principles. It is apparent that many scholarship candidates only had a surface knowledge of the ideas they were trying to explain or, if they did understand in more depth, they lacked the skills to write concise, well-reasoned discussion. Many candidates appeared to launch into writing their answers with little or no planning as to how they would use their knowledge to answer the specific question. They often wrote answers with no reference to the data they were supposed to be discussing or explaining. It is also of concern that when more than one thing was asked for in a question, a number of candidates left out answers eg in Questions 2(a) and 4(a)(i). This suggests more careful reading of questions was required.

It would be expected that scholarship candidates would be competent in their use of chemical symbols, formulae and equations. Chemical equations should be part of their chemical literacy and they should be able to use these appropriately in discussion and problem-solving.

Numerical questions (calculations) seemed to be more accessible to a greater number of candidates but their success with these questions was not matched by their understanding or insight into chemical principles and how they are used to explain the behaviour of substances or systems. Where a question asks candidates to ‘show by calculation’ it is expected that the calculation will be annotated in some way to show the relevance of the numbers/mathematics to the question. This was a particular problem for many candidates in Questions 1(b) and 2(b).

More than half the candidates were unable to score more than 20 marks (out of 94). With marks available for answers that showed a fair level of performance (four marks) or even a limited level of performance (two marks) candidates who were well prepared for NCEA Level 3 examinations should have been able to score some marks in each question. While it is acknowledged that there was no scaffolding (lead in) in the way the scholarship questions were designed, it would appear that many of those who entered for Scholarship in 2005 would have struggled to even reach Merit in the Level 3 examinations, so one would question their entry into the higher level examination.

The best-performing candidates most commonly demonstrated the following skills and / or knowledge:

- ability to complete all the questions to a high standard
- very good time management skills. This ensured their answers were carefully considered and planned, so as to be logical
- ability to write answers which addressed the issue and related knowledge to the required situation
- familiarity with experimental procedures
- coherent and concise use of equations, diagrams and chemical terms when appropriate
- ability to write concise, logical, well-thought answers to all questions requiring justification and discussion
- ability to correctly gauge the amount of information/detail necessary to provide a complete explanation of the chemical principles that related to the observations/ data given
- ability to link ideas from different areas of chemistry. Answers were related back to the data or observations, and calculations were accurate and linked to the conclusions drawn
- consistent demonstration of depth and breadth of understanding of chemical principles across all the areas of chemistry covered in the examination
- answers, when calculations were required, that were accurate, appropriate for the question and clearly set out with sufficient labelling, discussion or annotation for an assessor to follow the logic or reasoning in the steps involved.

Comments about specific questions

Question 1(a):
Best-performing candidates recognised the three different intermolecular forces present in the compounds given. They discussed the origin and relative strength of the forces and used the data given to compare their significance.

Question 1(b):
Best-performing candidates were able to use data to determine the reaction quotient Q (IP) for each metal ion and relate this to solubility or solubility product. Calculations were accurate and carried out in a logical order showing all working. Alternative methods were acceptable. Outstanding candidates were able to interpret their calculations to determine which metal ion was present in the greater amount and provided sufficient annotation of their working or discussion to show how this conclusion was reached.

Question 1(c):

Best-performing candidates linked the shapes of the molecules to the number of electron pairs on the central atom and hence to the number of valence electrons of the atom '*Z*' and its position in the periodic table. They usually drew Lewis diagrams and related these to the shape of the molecule by discussing the number of electron 'clouds' on the central atom, the number of non-bonding electron pairs and VSERP theory. They were able to discuss polarity in relation to the polar nature of the *Z-F* bond and the symmetry of the bonds around the central atom. Outstanding candidates recognised the need to discuss all aspects of the statement given and did so in a concise and logical manner using diagrams and symbols where appropriate.

Question 2(a):
Best-performing candidates were able to carry out the appropriate calculations for buffer systems and showed understanding of the relationship between the pH of the solution or the buffering ability and the relative concentrations of the species present. Outstanding candidates could correctly identify and discuss both of these including correct equations where appropriate.

Question 2(b):
Best-performing candidates were able to use the half equations given to write an equation to represent each of the systems under discussion. They were able to either calculate relevant cell potentials and discuss the significance of the values obtained in relation to the observation given or use the relative size of E^o values of couples containing the oxidant and reductant to determine whether a reaction would occur. Outstanding candidates were able to extend their discussion to include all the relevant reactions that could occur based on the data given.

Question 3:
Best-performing candidates correctly calculated the required ratio of Fe^{2+} to hydroxylammonium chloride, which meant they recognised the need to write a balanced equation for the titration and included the appropriate dilutions. Oxidation numbers were correctly calculated and the change of oxidation number was related to the number of electrons transferred in the redox reaction. Outstanding candidates used all the above information to produce a correctly balanced equation for the given reaction.

Question 4(a):
Best-performing candidates were able to correctly calculate the equilibrium constant required because they could use the titration data given to calculate the concentrations of the components of the system. The expression for the equilibrium constant they used considered all the contributing species (ie water was included because the only water present was a product of the reaction). Outstanding candidates showed a comprehensive understanding of equilibrium principles in their calculations and discussion.

Question 4(b):
Best-performing candidates showed an understanding of the concepts and skills inherent in practical work involving the synthesis and extraction of an organic compound and the reason why various steps are undertaken.

Question 5:

Best-performing candidates were able to determine all the appropriate structures that met the given requirements (without including repeats or ‘extra’ structures). They were able to apply their knowledge of the reactions of organic functional groups and their understanding of isomerism to devise a scheme to identify most of the five possible isomers. Outstanding candidates were able to present a scheme that was appropriate and would correctly identify all five possible isomers.

Question 6:
Best-performing candidates were able to relate the concentration of all species in the reaction vessel at different points in the titration to the relative conductivity and to sketch an appropriate graph. They recognised the similarities and differences of the two titrations to be graphed. Outstanding candidates took into account the dilution which would occur in the concentration of the ions as the titration proceeded and correctly represented both titrations on their graphs.

Other candidates commonly lacked the following skills and / or knowledge:

- ability to read questions carefully. They also showed little evidence of planning or thought in their answers. This often resulted in answers which looked more like a ‘brain dump’ ie a record of everything they knew about a topic rather than answers which related knowledge to the particular question asked
- ability to manage their time well, with the result that they did not complete the paper. On many occasions this was because they wrote far more than was necessary to answer a question. This was usually because of lack of structure in the answer or because the ideas were not explained clearly or concisely
- ability to write explanations with the rigour required at this level. Answers were often inaccurate or omitted important detail. Chemical terms such as electronegativity or H^+ were often used indiscriminately and formulae were sometimes incorrect
- ability to calculate accurately. Often when correct answers were obtained, the working was not present or there were gaps in the working which lead to illogical conclusions. Many candidates who could carry out the calculations correctly showed little understanding of the chemical principles involved.
- ability to make the links between the data given and their answers.

Comments about specific questions

Question 1(a):
Other candidates did not discuss all three of the intermolecular forces present in the compounds given. They did not take into account the polarity of the molecules given and failed to show understanding of the relationship between the number of electrons present in the molecule and the size of its temporary dipoles.

Question 1(b):
Other candidates failed to convert between *mg* and *g* and $g\ L^{-1}$ and $mol\ L^{-1}$; omitted to calculate the concentration of Cl^- in blood; or failed to recognise that if a compound is insoluble (forms a precipitate) it will *not* remain in the blood.

Question 1(c):
Other candidates tended to focus on the molecules that illustrated the shapes described rather than discuss all aspects of the statement given. They frequently chose the

wrong element for '*Z*' and, hence, used ions rather than molecules to illustrate the shapes under discussion. They did not relate shapes to the number of electron clouds on the central atom and the repulsion between electron pairs (VSEPR), but made statements such as "adding a nonbonding electron pair would distort the tetrahedron". Discussion of polarity often lacked clarity.

Question 2(a):
Other candidates did not recognise that in a buffer system $[A^-] \neq [H_3O^+]$ and so did not know how to use the pH given to calculate the required ratio. Some candidates did not carry out a calculation for [acid]:[base] but relied for their answer on the difference between pH of buffer and p*K*. This meant their discussions had little depth or substance. Others who could correctly calculate the ratio did not understand how the calculation related to the buffer properties ie they could not relate the ratio of [acid]:[base] to the effectiveness of the buffer system.

Question 2(b):
Other candidates tended to calculate $E°$(reaction) without giving any reference to a specific reaction or reaction equation. They would often not explain how the spontaneity (or not) of the reaction was determined. Many seemed confused by being given $E°$ for half equations rather than half cells and, therefore, were unable to use the equations given to write equations to represent the systems under discussion.

Question 3:
Other candidates usually did not write an equation for the titration reaction or were unable to balance this equation because they failed to recognise the need to begin with balanced half equations. They often missed the dilution factor in their answer or were unable to correctly calculate the oxidation numbers of nitrogen in the various species. Most candidates failed to equate the change in oxidation number with the number of electrons transferred.

Question 4(a):
Other candidates did not understand that this was a 'back titration' and so could not correctly carry out the calculation to determine the concentration. Others did not understand how to use the information about the only water present being produced by the reaction. This meant they failed to include water in the *K* expression ie it was not constant). Many did not know how to calculate percentage yield. Discussion about the change in equilibrium concentrations failed to take into account that *K* does not change if the temperature remains constant.

Question 4(b):
This question was attempted by the majority of candidates. Other candidates often failed to refer to the equilibrium nature of the preparation procedure when considering the effect of the actions given on the % yield. Other omissions or errors included not recognising concentrated sulfuric acid as a catalyst and/or that a catalyst does not affect equilibrium concentrations and, therefore, yield; confusing reflux and distillation; thinking that the equilibrium reaction occurred during the distillation procedure; not knowing that anhydrous calcium chloride is a dehydrating agent; or not describing the effects of actions on the purity of the product. Many did not understand the difference between yield and purity.

Question 5:
In determining the structures of the relevant compounds, other candidates tended to duplicate versions of the same molecule, include straight-chain isomers or miss the ‘3 C chain’ isomer. Schemes for identifying alcohol used often failed to identify both isomers with optical activity – or identified the wrong ones – and did not give expected observations for reactions. Other omissions or errors in the schemes included failing to clarify which compounds (from Question 5(a)) were identified by the given procedures; using reactants that were not on the list provided; using speed of reaction as the determining factor for distinguishing between primary and secondary alcohols using acidified dichromate; confusing thionyl chloride with the Lucas test; or not chlorinating the alcohol (using thionyl chloride) *before* the elimination reaction.

Question 6:
Other candidates showed a lack of understanding of the changing nature and concentration of the ions present in solution as a titration proceeds. When comparing the two titrations, they failed to recognise that the relative conductivity of chloride and ethanoate ions are the same and, hence, the conductivity at and after the equivalence point will be the same. Others assumed different volumes were needed to reach equivalence point. Many did not recognise that ethanoic acid has a much lower concentration of [H_3O^+] than HCl has (<1%) and so started the second graph too high.