Assessment Report

Scholarship, 2008

Chemistry

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COMMENTARY

Around 19% of the NCEA level 3 Chemistry cohort sat the Scholarship examination in 2008, a similar percentage to previous years although there was an increase in the number of papers. This year, however, candidates found the examination more challenging and there were more papers submitted with questions left not attempted. While the standard of answers to the organic chemistry questions had shown considerable improvement over the years, candidates had difficulty writing coherent, concise explanations. They also had difficulty solving problems outside of those using practised routines and with unfamiliar data presented to them.

Top performing candidates were well prepared with a sound knowledge of chemical principles and concepts. They applied their knowledge to solve problems, including calculations that were unlike any they would have seen before. It was usually their logical and concise answers which used the appropriate chemical principles, along with accurate calculations and evidence of good time management that distinguished them as top scholars.

The calculations appeared to challenge candidates more than usual this year, not because they were using skills that were unknown at this level, but because candidates needed to understand the nature of the problem concerned in order to determine the equations or routines to be used.

Most candidates appeared to begin in the middle of the paper with the questions about bonding and atomic structure. It seemed that this was where they were most confident in their chemical knowledge. However, the rambling answers given were usually not well thought out and, while they were on the right topic, did not always answer the question directly. It is a concern that chemical terms and vocabulary are used inappropriately or with little attempt to define or suggest the relevant meaning. Many candidates stated that adding electrons to an atom increased electron to electron repulsions but they did not understand how this influenced the properties of the atom or ion. Two terms that were poorly understood are “shielding” and “effective nuclear charge”. Shielding (or screening) can best be understood as the cancelling out of a portion of the attraction between the nucleus and the valence electron by electron-electron repulsions from inner shells or “core” electrons. Effective nuclear charge is the net positive charge, equal to the nuclear charge minus the effects of screening, that an electron in an atomic orbital experiences.

The Scholarship Chemistry Performance Standard states that “the assessment will be based on the Achievement Standards at Level 2 and Level 3”. The first question in the paper combined skills and knowledge from level 2 with those from the level 3 oxidation–reduction standard. It was disappointing that this question was very poorly done or not attempted at all by many candidates.

The higher order thinking skills required of candidates at this level should see them using a wide range of chemical knowledge, concepts and principles to provide explanations and to solve problems. They should be able to show that they can make connections between different aspects of chemistry for themselves and that they know what is appropriate and necessary for a complete and coherent explanation. For example, very few candidates, in their discussions about the dissolving of salts, mentioned the bonds between the water molecules that needed to be broken before the solutions could be formed. In Question 4, candidates were not specifically told to write an equation. However, much has been said in recent years about the approach to understanding chemistry at this level, with equations or formulae being an expected part of any chemistry discussion. When candidates recognised the need to write equations for the reactions described, the answer to the latter part of the question was much more obvious. Without an equation it was very difficult to recognise and discuss the nature of the equilibrium reaction in the question.

Candidates should be guided by the amount of space provided as to the expected amount of writing needed for an answer. It would be helpful if they could indicate when they have completed an answer on a page other than the one provided.

Most candidates showed good understanding of:

- atomic structure
- intermolecular forces
- functional group transformations
- the relationship between structure and basicity.

Many candidates had difficulty with:

- recalling solubility rules
- applying their understanding of atomic structure to answer questions logically
- using bond enthalpy data to interpret relative stability of molecules
- interpreting the Latimer diagram to retrieve electrochemical data
- using the appropriate number of significant figures in their answers
- calculations in unfamiliar contexts.

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

- ability to write logical and coherent responses, showing some evidence of planning
- ability to link their knowledge of chemistry directly to the context of the question asked
- correct use of chemical vocabulary and definition of terms when necessary
- ability to carry out accurate calculations, showing working clearly and using significant figures appropriately
- an accurate and detailed understanding of chemical concepts especially in answers relating to atomic properties and intermolecular forces
- ability to apply knowledge in unfamiliar settings – particularly in relation to calculations
- ability to recall and use appropriate concepts from all the NCEA level 2 and related level 3 Achievement Standards
- ability to recognise the need to support answers with balanced equations.

In Question 1 they:

- recognised the insoluble iron(III) salts
- used $E°$ data appropriately
- recognised the amphoteric nature of the Fe(III) and Zn(II) hydroxides
- wrote balanced equations for reactions
- recognised how the pH dependence of the Cr(VI) species and that Ag^+ forms a precipitate of Ag_2O with OH^- and a complex ion with NH_3
- used Ks and titration data appropriately.

In Question 2 they:

- identified functional groups from the reactions
- used data about isomerism appropriately

- devised a sensible scheme taking into account the order of reactions to protect functional groups when necessary.

In Question 3 they:

- discussed how the trend in melting points was related to the increasing number of electrons and hence the greater instantaneous dipoles rather than the differences in polarity
- carried out calculations to compare the enthalpy of decomposition reactions and linked the difference in $\Delta_r H$ to the observations
- linked the difference in acidity to the influence of the more electronegative fluorine atom
- logically discussed both models supplied with reference to the data given
- used terms appropriately to discuss atomic properties, showing a good understanding of atomic structure in relation to atomic size.

In Question 4 they:

- were able to access the $E°$ from the Latimer diagram
- wrote balanced equations for the reactions being discussed
- used equilibrium principles to discuss pH
- correctly used the dissociation data to calculate pK_a and hence the pH of the solution
- linked the disproportionation data to the titration practice
- understood the nature of titrations so as to interpret the data given for the calculation.

In Question 5 they:

- knew how to use the heat capacity data
- related the data given to their understanding of the dissolving process.

Candidates who did NOT achieve scholarship lacked some or all of the skills and knowledge above and in addition they:

- were unprepared for the lack of scaffolding in the questions
- misunderstood what was required from the questions and how to use the data that was given
- did not attempt all questions
- appeared to have large gaps in their knowledge and left out all questions in one topic
- showed misconceptions in their understanding of chemical principles
- stated facts without linking them to the question asked
- used chemical jargon without explaining the meaning of the words
- did not explain their ideas clearly or concisely
- analysed questions based on the standards, and so were unable to deal with questions that required a response using skills and knowledge from several standards.

In Question 1 they:

- could not recall solubility rules and colour of solutions/precipitates
- were unable to use $E°$ appropriately
- did not write equations for reactions
- assumed that $Cr_2O_7^{2-}$ was reduced to Cr^{3+} by being in basic conditions
- use the K_s data to calculate solubility rather than recognising the common ions effect.

In Question 2 they:

- failed to take into account the isomer data
- did not know when to use NaOH(aq) and NaOH(in ethanol)
- only tried one structure initially and did not adjust if that option was shown to be wrong
- did not write complete structural formulae
- used HCl to substitute for OH in a carboxylic acid group
- reacted an amide with a carboxylic acid to make (incorrectly) an amide
- made a "soup" of reagents in the hope that they would react to form the required product.

In Question 3 they:

- only considered one type of intermolecular attraction in determining the state of the different molecules
- used the term van der Waals
- did not recognise the trend in electronegativity difference for the trihalides
- only related stability to the bond enthalpy of the substance decomposing without taking into account the products formed
- linked the size of instantaneous dipoles to atom size
- stated what they knew about ionisation energy and size of species but were unable to use this knowledge to answer the question
- wrote about first and second ionisation energies which did not help answer the question
- gave the trend as a reason rather than explaining the trend
- attributed ionisation energy or radius to (the loss of) sub-shells or orbitals, rather than energy levels
- used the terms "electron repulsion" and "effective nuclear charge" without a clear understanding of what these phrases meant
- used the term "polar" in their explanations of ionic species
- failed to recognise the significance of the energy level in which and electron is found and hence ignored the effect of distance on the ionisation energy and radius of an atom.

In Questions 4 they:

- could not write balanced reduction-oxidation equations – many left them as half equations
- did not complete $E°$ calculations to support written answers
- did not realise that the reactions were occurring in basic conditions and so would be pH-dependent
- could not use the 7.6% dissociation to start the question
- did not take into account the 1:2 ratio of the ions in the formula
- did not use all the titration data supplied
- did not recognise the need to use the total volume.

In Question 5 they:

- tried to use inappropriate heat capacity of water data
- did not recognise the need to use Hess's Law or could not use it correctly
- did not write equations for reactions
- did not make sense of the data provided.