

# Assessment Report

## New Zealand Scholarship Chemistry 2021

### Standard 93102

#### Part A: Commentary

Candidates should ensure that they have prepared for this examination by studying and developing an understanding of the various different aspects of the Chemistry curriculum, regardless of which internal or external assessments they have entered for in NCEA. The questions in the examination are drawn from quantitative analysis, organic chemistry, spectroscopy, redox and electrochemistry, rates of reaction, chemical equilibria, aqueous systems, particles, substances, and thermochemical principles. Candidates who were successful in this examination were able to interpret and answer a majority of the questions, regardless of which area of the curriculum they were derived from. Candidates who did not reach a grade high enough for the awarding of Scholarship often had left large parts of the examination unanswered.

Each part of a question contributes evidence towards the awarding of Scholarship, and unanswered questions led to limitations on the grades that could be given for the candidate work. Candidates should attempt all parts of questions, as even a partially correct or incomplete answer has the potential to contribute more evidence towards the awarding of a scholarship grade than an unanswered question. The answers that were expected from candidates were not significantly different to the answers they would be expected to produce in NCEA Level 3 Chemistry examinations and internal assessments at Merit or Excellence level.

Candidates who were able to carry out calculations correctly, as well as write extended explanations, showed greater understanding than candidates who performed well in only one of those areas. Calculations can be reasonably predicted, for example, for quantitative analysis, electrochemistry, aqueous solubility, buffers, and acid-base titrations. Extended explanations can be reasonably predicted, for example, for questions related to thermochemistry, particles, particle interactions, and spectroscopy. In addition, candidates who had a strong understanding of organic functional groups, properties of organic compounds, reactions involving changes to functional groups, carbon bonding environments and the drawing of structural formulae, performed well in these areas of the examination.

Unsuccessful candidates often misinterpreted questions, or were unable to provide an answer that addressed the primary idea in the question. For example, in question 2(b) many candidates misinterpreted the solubility products provided for sodium chloride and calcium carbonate, and wrote extended explanations incorrectly discussing the insolubility of sodium chloride. Some candidates attempted to predict and discuss the various enthalpy changes associated with different steps of the dissolution process for each solid, despite being told the overall enthalpy change in the question. Candidates who performed well in this question understood the solubility products and followed the guidance in the question to address the entropy changes occurring in the solute, solvent, and solution, to provide logical reasoning towards the observed solubility of each solid. Candidates who performed at outstanding level were able to take their discussions a step further and discuss the decrease in entropy that led to the low solubility of calcium carbonate.

In questions involving calculations, those candidates that were successful were able to complete answers that were neatly laid out and showed clear working. These candidates often carefully worked through all parts of the calculations to ensure that they had accounted for all appropriate values and changes. For example, in question 2(a) the titration with sodium hydroxide involved reactions with both the ethanoic acid and oxalic acid, and upon evaporation of all liquids, the samples contained both oxalic acid and sodium chloride. In question 1(c), the addition of hydrochloric acid decreased the



concentration of the weak base, but also simultaneously increased the concentration of the conjugate acid. Candidates recognised these factors were able to correctly calculate the final values for these questions, while candidates who did not consider these factors often had incorrect final values. Failure to carry out extended calculations without introducing rounding errors, or correctly use significant figures and units in line with the data provided in the questions, can prevent a candidate from being awarded grades at the outstanding level.

Candidates who could discuss the intermolecular attractions between the particles of organic substances, the links between electron orbitals and ionisation enthalpies, spectroscopic data, and oxidation-reduction processes, performed significantly better overall in the examination than those who could not discuss the importance and relevance of these factors to the examples given in the examination.

Being able to answer questions related to any area of the Chemistry curriculum is essential to achieving in this scholarship examination. Regardless of which internal and external standards that candidates have been supported through in their schooling, additional preparation should be carried out for all other areas of the curriculum, to ensure a thorough base of knowledge going into the examination.

Due to the differences in layout, scaffolding, and style of questions between NCEA level 3, and scholarship, candidates who have experience with working through past scholarship examination questions ahead of the examination will be best prepared for the unfamiliar contexts and problem-solving required to answer the questions. Past examinations should be attempted ahead of the current year's examination, but it is essential that candidates develop problem solving skills, insight and independent thought, as those candidates who attempt to answer a new question based solely on reapplication of a method shown in a historical marking schedule, often miss key pieces of information or data, and get only part way through a question, or answer it incorrectly.

In discussing thermochemical principles at this level, Gibbs free energy is not required for scholarship performance. Candidates who perform well are able to relate enthalpy changes to surroundings entropy, changes to the arrangement of particles to system entropy, and then relate both entropy changes to the total entropy change for a given reaction, and the observed or predicted spontaneity of that process.

For organic structures, particularly in discussion of spectroscopy data or elimination/addition reactions, the numbering of carbon atoms in structures improves the communication of bonding environments and positions of atoms. Skeletal structures do not enable candidates to show awareness of the full structure of organic compounds, particularly the number of each type of atom present, and the location of those atoms, and should be avoided.

Overall, those candidates who were awarded scholarship and outstanding scholarship had prepared well for the examination, produced a greater quantity of correct answers, showing a broad and deep understanding of chemistry at this level.

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## Part B: Report on Performance

Candidates who were awarded Scholarship with **Outstanding Performance** commonly:

- could correctly complete calculations to determine  $Q_s$  values
- could compare and contrast the  $K_s(\text{Ca}(\text{OH})_2)$  with  $Q_s$  values to justify the presence or absence of a precipitate
- used equilibrium equations and principles to justify the loss of a hydroxide precipitate on addition of dilute acid
- justified redox changes of varying complexity with use of balanced equations and cell potential calculations
- could correctly calculate the changes in concentration of the weak base and conjugate acid species on addition of dilute acid
- understood the links between the states of different chemical species and their presence/absence in mixtures
- considered the reaction of oxalic acid with sodium hydroxide in the determination of the mass of ethanoic acid present in the mixture
- were able to interpret spectroscopic data and determine the structure and name for organic compounds
- recognised that the obvious entropy changes for system and surroundings, and therefore total entropy change did not match the stated  $K_s$  of  $\text{CaCO}_3$ , and so attempted to find a logical reason for this
- provided a reasoned justification for the differences in the solubility of  $\text{CaCO}_3$  and  $\text{NaCl}$ , with consideration of changes in the entropy of the solvent and solution
- were able to draw 3D structures for a polyatomic ion

- justified the molecular geometry for a polyatomic ion with consideration of the position of the lone pair of electrons and differing atoms bonded to the central atom
- were able to use quantitative data to calculate two or more masses in a mixture.
- solved the correct molecular formula for the unknown structure, and produced all possible isomers for the oxidation reactants and products
- justified the attractive forces present between aldehyde, ketone, alcohol, and carboxylic acid particles, and related these to the expected boiling points of the various compounds under distillation (and deduced the correct order for distillation)
- communicated understanding of carbon bonding environments with use of clearly labelled diagrams
- understood disproportionation reactions, and identified all oxidants and reductants
- could write a balanced chemical equation involving two oxidants and one reductant
- related the large second ionisation energy, and position of the electron in a lower energy level/orbital, to the lack of  $\text{CsF}_2$  existing
- could integrate the equations and terminology provided to justify thermochemical changes
- understood the relationship between ionic charge and radii, attractive forces, and enthalpy changes
- proposed and named organic structures that linked to given spectroscopic data.

Candidates who were awarded **Scholarship** commonly:

- could determine the concentration of species from mass and volume values, and use these to determine  $Q_s$  values
- calculated the pH of a buffer solution
- used standard reduction potentials to calculate cell potential values and write balanced equations for the relevant redox reaction
- could determine constitutional isomers from a molecular formula.
- correctly calculated the number of electrons present in a polyatomic ion and used this to determine various possible seesaw and trigonal pyramidal shapes
- justified the solubility of  $\text{NaCl}$  with consideration of the enthalpy and entropy changes occurring
- clearly communicated the change in entropy of the system and the entropy of surroundings for given processes and related the total entropy change to the  $K_s$  and therefore the solubility of ionic salts
- could solve the molecular formula  $\text{C}_4\text{H}_{10}\text{O}_2$
- understood the correct conditions for organic synthesis.
- understood the reaction of alkene to diol with use of acidified potassium permanganate solution
- determined the isomers for  $\text{C}_4\text{H}_{10}\text{O}$ , and oxidation products, and were able to rank these in order of boiling point with some reasoning
- recognised that the separation of the 9 compounds was mostly affected by the position of the functional group, the ability to form H-bonds and the packing of molecules
- could use thermochemical data to calculate an enthalpy change
- were able to distinguish between oxidation-reduction and oxidants and reductants
- could determine the oxidation state of elements and relate changes in states to oxidation-reduction
- referred to the correct species involved in oxidation-reduction reactions
- used quantitative data to calculate the mass of a substance in a mixture
- calculated an enthalpy change using Hess's Law
- related the lattice enthalpy of ionic substances to the charge and ionic radii of the ions present
- interpreted the provided spectroscopic data to propose organic structures, without naming them.

Other candidates

Candidates who were **not** awarded Scholarship commonly:

- did not show correct understanding of chemical equilibria
- did not understand the formation of calcium hydroxide from the reaction of calcium with water, despite the  $K_s$  value provided
- could not determine oxidation states for elements
- could not calculate  $Q_s$  values from concentrations

- assumed that the pH of a calcium hydroxide solution would be 7, and then incorrectly used this as the basis for the hydroxide ion concentration in  $Q_s$  calculations
- did not correctly balance oxidation-reduction equations
- were unable to correctly calculate cell potentials from standard reduction potentials for given situations
- could not calculate the pH of a buffer solution
- were unable to carry out quantitative calculations involving mass, moles, volume, and concentration when presented with a quantity of data
- could not determine the Lewis structure for a polyatomic ion
- attempted to use Gibbs Free Energy, and the temperature of the solution, to justify the differences in observed solubilities
- described the state changes occurring with the dissolution of a salt as being solid to liquid
- could not relate a  $K_s$  value to the solubility of an ionic compound, and argued  $\text{CaCO}_3$  was highly soluble, and  $\text{NaCl}$  had limited solubility
- were unable to correctly interpret the information provided in the question relevant to valence electron shell repulsion theory
- confused the reactants and products of the alkene oxidation reaction
- did not understand the concept of constitutional isomers
- could not draw structures for the compounds produced by oxidation from the 4 isomers of  $\text{C}_4\text{H}_{10}\text{O}$
- focused on the molar mass as the only reason for the difference in boiling points of compounds with reasonably similar molar masses
- did not describe the attractive forces between molecules of various substances
- could not determine the structure of an ester with 5  $^{13}\text{C}$  peaks and/or missed the conditions required in ester formation
- could not assign oxidation numbers to elements
- could not balance oxidation-reduction equations
- did not understand the relationship between ionic charges and lattice enthalpy
- made errors in their Hess's Law calculation
- could not use spectroscopic data to propose organic molecules that matched that data
- could not identify correct functional groups from spectroscopic data
- did not understand that the yellow solid formed in the disproportionation reaction was sulfur
- made errors in the drawing of organic compounds e.g. 5 bonds around C
- left whole questions blank.
- were unable to approach a question with multiple stages or parts
- could not apply Level 3 chemistry understanding to unfamiliar contexts
- could not communicate chemistry knowledge
- did not manage time effectively
- do not appear to have practiced past scholarship exam questions
- applied a rote-learned method to a question which required a different approach

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