Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Assessment Report

New Zealand Scholarship Chemistry 2024

Performance standard 32102

General commentary

The examination required candidates to answer a broad range of questions and demonstrate a deep level of understanding of Chemistry. Successful candidates demonstrated understanding of organic reaction schemes, interpreted spectroscopic information, completed quantitative calculations, discussed the particles and particle interactions involved in the dissolving and melting points of solids, explained solubility and acid-base equilibria, explained spontaneous processes and complete thermochemical calculations, and demonstrated understanding of electrochemical processes.

The Scholarship Chemistry assessment specifications emphasise that the examination is specifically designed to evaluate a broad understanding of the Chemistry curriculum. Candidates with a limited grasp of certain areas of the curriculum, often due to exposure to a narrow, selective range of achievement standards, are at a clear disadvantage. Candidates that demonstrated a breadth and depth of knowledge from across the curriculum were able to cope with unfamiliar and abstract situations, and suitably rewarded.

Each question provided opportunities for candidates to demonstrate critical thinking, depth, insight, integration, detail, and accuracy. Candidates who did not answer significant portions of the exam are unlikely to meet the Scholarship threshold.

The quality of written communication is also considered. Candidates who provided unclear explanations, made significant calculation errors, or included irrelevant or incorrect chemistry principles, did not perform as highly as those who delivered well-crafted responses. Some candidates attempted to use advanced concepts from university-level reading to answer straightforward questions, or advanced calculations when written explanations were required. These strategies often failed to address the simpler parts of questions, or provide the correct explanations, resulting in limited success. Such approaches are discouraged.

Common errors, omissions, or misconceptions that were observed included missing units in calculation answers, incorrect or inaccurate terminology, not clearly explaining that intermolecular forces (such as TD forces or hydrogen bonds) are between molecules, missing atoms or reacting incorrect functional groups in organic schemes, or not using key terminology expected in questions. Many candidates did not adequately label organic structures or make appropriate references in equilibrium discussions.

Calculations were part of every question in this examination. Question One involved quantitative calculations, Question Two included buffer calculations as well as solubility calculations, Question Three had cell potential and titrimetric calculations, and Question Four included a thermochemical Hess's law calculation. Candidates who were better prepared to complete mathematical calculations often yielded significantly better outcomes than those who were not or left these questions blank or incomplete.

Report on performance standard

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

- completed the entire examination
- demonstrated a wide breadth of curriculum understanding
- completed calculations related to the water of crystallisation in epsom salts and discussed the entropy changes occuring during the rehydration of the anhydrous salt

- discussed the peaks present in IR and ^{13}C NMR spectra in relation to the unknowncompounds
- demonstrated awareness of chiral carbons when constructing the correct branched structures for unknown organic compounds
- clearly explained the number and types of unique carbon bonding environments in ^{13}C NMR spectra, with clear links to structures including symmetry where present
- demonstrated sound understanding of solvent-solvent forces, solute-solute forces, and solvent-solute forces involved in the dissolving of a solute in a solvent
- justified the solubility of different ionic and molecular solids in water, with clear links to particles and attractive forces
- recognised that citric acid dissociates to form ions and articulated the subsequent interactions with water
- justified the pH of different aqueous solutions with support of balanced equations and a description of the relative concentration of species
- calculated the pH of the buffer solution
- justified experimental observations in precipitaiton reactions with support of balanced and clear knowledge of equilibrium changes
- calculated the correct Q value for the unknown solution and compared to both Ks values to justify the ion not being Mg^{2+}, and concluding it as being Ba^{2+}
- determined the modification in external voltage that was required to enable electrolysis of salt water to occur, with support of balanced equations, observations, and cell potential calculation
- calculated the concentration of hypochlorite in the pool solution in grams per litre
- justified acid and base hydrolysis of nylon with support of correct structures for hydrolysis products
- clearly explained the correct monomers to be used in the formation of nylon-6 and nylon-6,6, with support of a clearly drawn structural equation
- concisely justified errors in the provided reaction scheme with suitable alternative reagents or steps, with all final products for the provided scheme being identified correctly
- correctly calculated the energy release from the black powder reaction
- provided comprehensive explanation of the particles and particle interactions present in the four different substances to justify PCl_3 as being the only liquid at room temperature
- wrote clear precipitation equilibrium equations, and explained the effect of added acid and the formation of complex ions on the precipitate using balanced equations
- recognised that the reduction of water resulted in an alkaline solution
- chose concordant titres carefully
- recognised the effect of the amount of moles on the energy released
- recognised SiO_2 as covalent network and methylammonium chloride as ionic and could clearly identify specific particles and forces and the effect they had on the state at room temperature.

Candidates who were awarded **Scholarship** commonly:

- completed a wide range of questions in the examination with very few left unanswered
- calculated the water of crystallisation in epsom salts and the mass required to produce the solution
- correctly explained IR and ^{13}C NMR peaks in relation to the unknown compounds
- linked peaks in IR spectra to potential functional groups and the molecular formula of an unknown compound
- solved, with minor errors, straight chain structures for the unknown organic compounds

- explained the solubility of ionic and molecular compounds in water with links to particles and attractive forces
- recognised the relative solvent and solute interactions in the process of dissolving and linked these to specific interactions between particles
- explained the pH of different aqueous solutions, with support of either balanced equations or relative concentrations of species
- calculated the pH of the buffer solution with minor error
- explained the observations for experimental reactions involving carbonate ions, or chloride ions, with support of balanced equilibrium equations
- calculated, with minor error, the Q value for the unknown solution and identified the cation as Ba^{2+}
- identified the change in voltage required to enable the reaction to occur for the electrolysis of salt water, with support from(?) a range of: the correct cell potential, balanced equation, observations
- calculated, with minor rounding errors, the correct concentration of hypochlorite in the pool solution in mols per litre.
- explained acid and base hydrolysis of nylon with support of organic product structures with minor errors
- explained appropriate monomers to be used for nylon-6 or nylon-6,6 synthesis with support of a structural equation
- explained a small number of errors in the provided reaction scheme with some descriptions of alternative reagents or steps, and identification of some final products for the provided scheme
- completed a complicated Hess's law calculation with minor error
- justified the state of some of the provided compounds with clear links to particles and particle interactions
- wrote correct and clear equations for the reaction of neutral, acidic, basic and buffer solutions with water and linked the products to the pH
- recognised ethanamide as having hydrogen bonds between molecules and PCl_3 as a polar molecule with permanent dipole forces between molecules.

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

- did not complete a number of questions in the paper
- did not apply Level 3 chemistry understanding to unfamiliar contexts
- did not communicate using appropriate chemistry vocabulary
- did not manage their time well across the paper
- did not appear to have experience with NZ-Scholarship-level questions
- provided rote-learned responses to questions which required a different approach
- did not correctly interpret IR spectra
- did not relate peaks on ^{13}C NMR spectra to the number or type of unique carbon bonding environments present in structures
- did not determine the structure for organic compounds or correct functional groups
- did not discuss particles and particle interactions correctly when attempting to explain solubility
- did not have a clear understanding of hydrogen bonding between different molecules
- did not understand ionic lattices
- did not explain the pH effects of simple compounds on water
- did not write correct balanced equations for solutions containing weak acids, bases, or salts
- did not complete a calculation for a buffer solution
- did not write balanced solubilty or complex ion equilibrium equations

- did not correctly explain equilibrium changes occuring during reactions
- did not complete calculations for solubility equilibria
- incorrectly determined a cell reaction occuring during electrolysis of salt water
- incorrectly calculated a cell potential
- did not provide balanced redox equations, observations, or cell potential calculations to justify a change in the energy supply of the cell
- incorrectly completed a titration calculation
- did not to identify the correct products of acid or base hydrolysis of a polyamide
- did not determine correct monomers to be used in the formation of a condensation polymer
- did not identify errors in a reaction scheme
- did not propose appropriate alternative steps to enable organic synthesis to occur
- did not determine the correct structures for the organic compounds which would be produced from the provided scheme
- did not correctly complete a thermochemical calculation using application of Hess's law
- stated energy released as a negative value
- did not identify or explain the particles or particle interactions present in different chemical substances
- did not recognise SiO_2 as a covalent network substance, methylammonium chloride as ionic, or PCl_3 as polar
- had poor written communication – often wrote hard to read and interpret sentences
- used generic language rather than specific
- did not show clear working for calculations
- did not write clear equations for the reaction of simple acids, bases, buffers and neutral compounds
- did not recognise an alcohol as neutral in the context of a question where other substances were weak acids or basic salts
- did not calculate a cell potential
- used reactants that were not available to react in an electrolytic cell
- confused ester and amide linkages
- did not recognise reagents and conditions required for organic reactions
- did not correctly respond to the questions asked, e.g., completed calculations when told calculations were not necessary.