

Assessment Report

New Zealand Scholarship Chemistry 2023

Performance standard 93102

General commentary

Candidates who had a broad knowledge of the level 3 curriculum achieved well in the examination this year. Successful candidates carried out quantitative calculations, discussed atoms, molecules and ions, and were able to interpret spectroscopic data. They completed calculations for aqueous and organic reaction schemes, and carried out thermochemical calculations. Successful candidates explained how electrochemical and thermodynamic factors affected spontaneity, clearly articulating factors that affected the rates of reactions, while demonstrating their understanding of oxidation-reduction reactions.

Each response to a question was awarded a grade between 0-8 depending on the level of critical thinking, depth, insight, and integration shown, as well as the level of detail and accuracy provided. Some candidates attempted to use higher-level concepts to explain a simple answer, perhaps from extension reading of university level texts, however this approach often did not address the question, nor provide the right explanation, yielding limited success; candidates should be dissuaded from such an approach in the future.

Calculations were part of every question in this examination. Question One involved aqueous solubility calculations, Question Two involved aqueous pH and thermochemical calculations, Question Three involved iodometric titration calculations, while Question Four involved electrochemical and acid-base titration calculations. Candidates who were better prepared to complete mathematical calculations often yielded significantly better outcomes than those who left these questions blank or incomplete.

Report on performance standard

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

- showed a wide breadth of conceptual understanding
- calculated K_s for $\text{Pb}(\text{OH})_2$ in water and explained the acidification of the $\text{Pb}(\text{NO}_3)_2$ solution
- clearly communicated the scientific rationale for the impact of elevated temperature, and the presence of a catalyst, on the rate of the reaction occurring in the demonstration
- could draw Lewis structures for the anions, including predicting the shape and bond angles for ZrF_7^{3-}
- justified the boiling points of different molecular compounds, with clear references to temporary dipole attractions, permanent dipole attractions, hydrogen bonding between molecules, and molecular packing
- clearly explained that hydrogen bonding was between molecules, and elaborated on the strength of the intermolecular attractions, based upon the electronegativity differences of the oxygen and nitrogen atoms
- determined the identity of the amide and ester compounds present in the reaction mixture

- demonstrated understanding of acidic and basic hydrolysis, including the formation of charged ions
- justified the distillation of molecular species from an aqueous mixture, and explained the ion-water forces present that restrict the distillation of charged species
- correctly interpreted aqueous and thermochemical data to calculate the temperature change for the given reaction
- justified the total entropy change for a reaction, with explanation of changes occurring to the entropy of the system, and entropy of the surroundings
- carefully constructed organic reaction schemes using appropriate reagents and reaction steps
- calculated the mass of Vitamin C present in the packet, and the percentage of Vitamin C present following oxygen exposure, using given quantitative data
- could write balanced half, and full, oxidation-reduction equations for given reactions, and justified the identity of oxidants and reductants, with clear references to oxidation number changes of elements in the given species
- justified the differences in first ionisation energy and radii for the given atoms and ions
- used correct cell potential calculations to determine the final oxidation number, and colour of the vanadium species present in the three solutions
- correctly calculated pH values and volumes for strong acid-strong base, and weak acid-strong base titration curves
- correctly calculated the pH value for the intersection of two titration curves, based upon it occurring in the buffer region of one curve and the vertical region of the other.

Candidates who were awarded **Scholarship** commonly:

- calculated Q_s values for both mixtures and compared to K_s values to determine if a precipitate was formed in either solution or not
- explained how increases in temperature increase the kinetic energy of particles, leading to an increase in frequency of collisions, and the proportion of collisions which are successful
- explained how the use of a catalyst provides an alternative reaction pathway with a lower activation energy resulting in a greater proportion of successful collisions for a faster reaction
- gave Lewis structures, shapes and bond angles for ZrF_5^- and ZrF_6^{2-} , with supporting justification of the bond angles
- explained the boiling points of different molecular compounds, with clear links to intermolecular attractions and the atoms present in the structures
- interpreted spectroscopic information to determine the identity of compounds
- calculated a temperature change for a chemical reaction, using aqueous and thermochemical data, with minor errors
- explained entropy changes occurring to the system and surroundings in a chemical reaction
- interpreted information provided on unknown organic compounds to determine their correct structure
- constructed, with minor errors or omissions, organic reactions schemes for the formation of other compounds from given starting materials

- could calculate the concentration of the sodium thiosulfate solution utilised in the analysis and complete the remainder of the quantitative calculations with minor errors
- could account for the oxidant and reductant species present in a given reaction, with use of balanced half and full equations, and oxidation number changes
- defined and explained differences in the first ionisation enthalpy of oxygen and nitrogen, with clear references to variations in numbers of protons, and electron-electron repulsion in the p orbitals
- justified the differences in radii of the provided particles, with clear identification of the isoelectronic nature of the particles, and references to differences in the number of protons present in each nuclei
- carried out cell potential calculations to identify spontaneous and non-spontaneous reactions, to justify the final colour and oxidation number of the vanadium species present in a given solution
- calculated the pH values and volumes for a strong acid-strong base, or weak acid-strong base titration curve.

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

- attempted to calculate a Q_s value for either solution using incorrect concentrations.
- calculated the correct Q_s value but incorrectly determined the presence/absence of a precipitate in either solution.
- did not recognize that acid would neutralize OH^- ions in solution, preventing the precipitation of $\text{Pb}(\text{OH})_2$ when dissolving $\text{Pb}(\text{NO}_3)_2$ in water
- did not recognise the presence of a catalyst, or explain how a catalyst increases the rate of a chemical reaction
- did not explain particle collision theory in relation to the temperature of a reaction
- did not draw Lewis structure for anions, name the shapes, or provide correct bond angles for the shapes
- did not determine, account for, or compare the different intermolecular forces present between particles for different molecular compounds
- did not correctly interpret spectroscopic information to solve the identity of unknown compound
- did not determine the structure of an ester or amide given starting reagents
- did not use provided data and stoichiometric principles to correctly calculate the temperature change in a given reaction
- did not explain changes to the entropy of the system, or entropy of the surroundings, for a given chemical reaction
- did not interpret information on organic compounds to determine a correct structural formula
- did not identify appropriate organic reaction reagents in the construction of organic reaction schemes
- did not use given data, or correct stoichiometric principles, to carry out calculations for the quantitative analysis
- did not balance half and full oxidation-reduction equations
- did not to correctly identify, or explain, oxidation number changes
- did not identify oxidants and reductants in the given oxidation-reduction reaction.

- did not define first ionisation enthalpy
- incorrectly justified oxygen as having a higher first ionisation enthalpy than nitrogen
- incorrectly justified variation in the radii of the given particles with reference to changes in electron-electron repulsion, rather than changes in the number of protons present in the nuclei
- did not carry out correct cell potential calculations
- did not identify spontaneous and non-spontaneous chemical reactions using cell potential data
- did not calculate volume or pH values for a titration curve.