2024 NCEA Assessment Report

Subject:	Chemistry
Level:	3
Achievement standard(s):	91390, 91391, 91392

General commentary

Candidates who achieved Excellence were able to adapt and apply their knowledge to a range of contexts. The importance of incorporating practical work into class work was evident in responses to practical-based questions across all three standards. To achieve in each standard, candidates needed to improve their accuracy by taking care with drawing structural formulae, rounding in multi-step calculations, and giving correct charges on ions.

Report on individual achievement standard(s)

Achievement standard 91390: Demonstrate understanding of thermochemical principles and the properties of particles and substances

Assessment

The examination included three questions, of which candidates were required to respond to all three.

Question One focused on drawing Lewis structures and naming shapes, calculating the enthalpy change of a reaction using Hess' Law, and using entropy changes to justify the spontaneous nature of a reaction. Question Two covered explaining aspects of *s*, *p*, *d* notation, justifying trends in ionisation energy, and comparing possible molecular shapes given the stated polarity of the molecule. Question Three required candidates to explain differences in boiling points, with reference to the strength of the intermolecular forces present and use information from a calorimetry experiment to calculate the mass of water heated and explain a source of error.

The questions covered the requirements of the 2024 assessment specifications to demonstrate understanding of thermochemical principles and the properties of particles and substances.

Commentary

Candidates were expected to demonstrate a deep understanding of the material, rather than relying solely on rote memorisation. This approach required critical thinking and the ability to apply knowledge in various contexts.

Most candidates assumed that a trigonal planar shape could only arise from trigonal planar electron geometry, rather than trigonal bipyramidal electron geometry.

Many candidates did not round to the appropriate number of significant figures at the end of the calculation, instead rounding after each step, which affected the accuracy of the final answer.

Grade awarding

Candidates who were awarded **Achievement** commonly:

- drew Lewis structures and named shapes
- recognised how entropy could increase in the system and/or the surroundings
- partially applied Hess' Law to an enthalpy change calculation
- identified a factor affecting the trends in ionisation energy
- identified the polarity of a bond / molecule
- recognised that intermolecular forces exist between molecules.

Candidates who were awarded **Achievement with Merit** commonly:

- explained aspects of the entropy changes in the system or surroundings
- applied Hess' Law to an enthalpy change calculation
- explained the trends in first ionisation energy
- explained the effect of the size of the electron cloud on the strength of temporary dipole forces
- completed calorimetric calculations with one error
- explained procedural limitations to a calorimetric experiment.

Candidates who were awarded **Achievement with Excellence** commonly:

- justified the spontaneity of a reaction based on the entropy changes of the system and the surroundings
- justified the periodic trends in first ionisation energy in terms of the number of energy levels, nuclear charge, repulsion from inner energy levels, and the electrostatic attraction between the nucleus and valence electrons
- explained how the arrangement of bond dipoles around the central atom affects the polarity of the molecule
- explained differences in boiling points by comparing the strength of the intermolecular forces, including linking the strength of temporary dipole attractions to the surface area of the molecules
- calculated the mass of water heated in a calorimetry experiment
- completed all calculations with appropriate units and significant figures.

Candidates who were awarded **Not Achieved** commonly:

- did not name molecular shapes
- did not describe the entropy of the system/surroundings
- did not identify a factor influencing the trends in ionisation energy
- did not identify specific intermolecular forces between molecules
- did not recognise the effect of electronegativity on the formation of a bond dipole.

Achievement standard 91391: Demonstrate understanding of the properties of organic compounds

Assessment

The examination included three questions, of which candidates were required to respond to all three.

Question One focused on optical isomerism, devising a reaction scheme, condensation polymerisation to form a polyester, and hydrolysis of a dipeptide. Question Two required candidates to name and draw structural formulae of organic molecules, including drawing constitutional isomers, complete a flow chart by drawing structural formulae of organic products and identifying reagents, and justify structural formulae based on observations from chemical tests. Question Three covered explaining the steps involved in the synthesis of an ester, including heat under reflux and distillation, and using provided properties to draw and justify structural formulae.

The questions covered the requirements of the 2024 assessment specifications to demonstrate understanding of the properties of organic compounds.

Commentary

Candidates needed to draw structural formulae with accuracy to ensure the correct atoms were bonded to each other (e.g., carbon directly bonded to the oxygen of an alcohol group).

Candidates who understood types of organic reactions responded well to questions that required conversions or flowcharts, however, candidates needed to include conditions such as heat, and whether a reagent was concentrated, dilute, or dissolved in alcohol, in the reaction scheme/flowchart.

To explain reaction types, candidates needed to outline what happens during the reaction (e.g., the Cl atom is replaced by the OH group).

Practical organic chemistry should be encouraged wherever possible to allow candidates to understand different procedures (e.g., heating under reflux, distillation to purify an organic compound). This would allow candidates to understand why certain steps are carried out and the benefits of using a particular procedure.

Candidates should consistently use correct units when answering questions e.g., 99.1 °C rather than 99.1 or 99.1 degrees.

Grade awarding

Candidates who were awarded **Achievement** commonly:

- named and drew structural formulae of organic molecules
- drew an enantiomer to show a tetrahedral arrangement of the atoms / groups and described a asymmetric (chiral) carbon
- completed one correct conversion with a reagent and conditions or changed the position of the functional group in a reaction scheme
- drew a polyester with an ester linkage, and recognised the reaction as condensation
- circled an amide linkage, and recognised the breaking of the amide linkage as hydrolysis
- matched functional groups to observed chemical tests and the type of reaction occurring
- identified a reason for using heat under reflux
- demonstrated understanding that distillation could be used to separate organic compounds with different boiling points
- identified an organic compound or drew a structural formula given properties of the compound.

Candidates who were awarded **Achievement with Merit** commonly:

- drew a pair of enantiomers and used the presence of the asymmetric carbon to explain their existence
- drew a section of a condensation polymer and explained a condensation reaction
- completed several steps of a reaction scheme
- explained hydrolysis under acidic conditions, including protonation of the amine group
- drew constitutional (structural) isomers
- linked observations from identification tests to functional groups and reaction types
- explained the importance of reflux and/or distillation in a synthesis reaction
- explained identification of an organic compound using at least two properties
- deduced the structure of an organic compound based on a molecular formula and properties provided.

Candidates who were awarded **Achievement with Excellence** commonly:

- completed a reaction pathway/scheme with organic compounds, reagents, and conditions
- understood both acidic and basic hydrolysis of a dipeptide
- explained the identification of organic compounds with reference to observations, functional groups, and reaction types
- explained the processes of reflux and distillation, and their use in the synthesis of an ester
- deduced and justified the identification of organic compounds from their properties.

Candidates who were awarded **Not Achieved** commonly:

- did not draw or name organic compounds/functional groups
- did not recognise different reaction types such as condensation or hydrolysis
- did not link together a series of reactions
- showed limited understanding of the processes of distillation and reflux
- did not identify an organic compound based upon its properties.

Achievement standard 91392: Demonstrate understanding of equilibrium principles in aqueous systems

Assessment

The examination included three questions, of which candidates were required to respond to all three.

Question One focused on solubility equilibria, including calculating the solubility of a sparingly soluble solid, explaining the effect of complex ion formation and a common ion on solubility, and predicting precipitation. Question Two covered explaining how a buffer functions, calculating the mass of a basic salt required to prepare a buffer solution at a specified pH, and justifying the identification of three different solutions based on their pH and electrical conductivity. Question Three was set in the context of a titration curve, and included calculating the pH of a weak acid, drawing a section of the titration curve, calculating the pH of a buffer and evaluating its effectiveness, justifying the rapid increase in pH either side of the equivalence point, and comparing the pH at the equivalence point when the initial weak acid was changed.

All three questions required both explanations and calculations to gain Excellence. The questions covered the requirements of the 2024 assessment specifications to demonstrate understanding of equilibrium principles in aqueous systems.

Commentary

Some candidates calculated the diluted concentration of relevant ions when two solutions were mixed. Candidates needed to consider the ratio of ions in each solution before they were mixed.

Most candidates explained that a strong acid will be removed by the basic component in a buffer solution to form the weak conjugate acid and were able to support their explanation with the correct equation, however, some candidates incorrectly referred to OH^- ions neutralising the added strong acid.

Most candidates did not relate the colour of an indicator to the relative concentration of H_3O^+ and OH^- ions present in a solution.

Candidates struggled to correctly sketch the missing portion of the titration curve. Many simply drew a straight line. Very few candidates drew the correct shape with an initial sharp increase in pH followed by a flattening of the curve halfway to the equivalence point.

Few candidates could explain that:

- the pH increases rapidly just before the equivalence point as the solution can no longer buffer the addition of the NaOH
- the pH increases rapidly after the equivalence point since the HF has all been neutralised.

Few candidates related the K_a / pK_a to the strength of the conjugate base present at the equivalence point and its effect on the pH.

Grade awarding

Candidates who were awarded **Achievement** commonly:

- wrote the equilibrium equation and K_s expression for a saturated solution
- calculated the solubility of silver sulfate
- recognised silver ions form a complex ion with ammonia
- identified the effect of a common ion on solubility
- compared the ionic product with the solubility product to predict precipitation
- stated that the basic component of the buffer will react with added strong acid
- recognised that a solution requires ions for electrical conductivity
- calculated the pH of a weak acid
- identified one reason why the pH increases near the equivalence point.

Candidates who were awarded **Achievement with Merit** commonly:

- used equilibrium principles to explain the effect of complex ion formation and a common ion on the solubility of a sparingly soluble solid
- explained how a buffer solution functions when strong acid is added, with support from a relevant equation
- calculated the mass of a basic salt required to prepare a buffer solution at a specified pH
- linked the degree of dissociation to the concentration of ions in solution to compare the electrical conductivity of three different solutions
- calculated the pH at the equivalence point.

Candidates who were awarded **Achievement with Excellence** commonly:

- linked solubility to the concentration of individual ions in solution
- showed, by calculation, that a precipitate would not form when two solutions were added together
- justified the identification of three different solutions in terms of the degree of dissociation, the relative concentrations of $[H_3O^+]$ and $[OH^-]$, and the colour of the indicator
- calculated the pH of a buffer using the ratio of the weak acid and its conjugate base, and evaluated its effectiveness
- used K_a / pK_a values to explain how the pH at the equivalence point would be affected by starting with a weaker acid.

Candidates who were awarded **Not Achieved** commonly:

- gave the incorrect charges on ions
- did not dilute the concentration of ions when two solutions were mixed
- recognised a buffer will neutralise added strong acid
- referred to charged particles, rather than ions, when describing the electrical conductivity of a solution
- substituted incorrectly into expressions to calculate the pH of various solutions.
