2023 NCEA Assessment Report

Subject: Chemistry

Level: Level 3

Achievement standard(s): 91390, 91391, 91392

General commentary

Candidates who achieved Excellence had a full understanding of the Level 3 external assessment requirements. Although knowledge of the Level 2 material is assumed, candidates should expect the examinations to predominantly focus on content from Level 3, and therefore should not rely too heavily on their knowledge from Level 2. Furthermore, candidates are encouraged to understand the process of a calculation, rather than memorise steps, to ensure they can adapt and apply their knowledge to problem solve a range of calculations in different contexts.

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, explaining the shape and polarity of a molecule, explaining vaporisation as an endothermic process, and using entropy changes to justify the spontaneous nature of a reaction. Question Two covered justifying trends in ionisation energy and atomic radius, enthalpy calculations using enthalpy of formation data, and explaining the effect of changing the state of a product on the enthalpy change of a reaction. Question Three required candidates to explain differences in atomic and ionic radii, explain differences in boiling points with reference to the strength of the intermolecular forces present, and calculate the enthalpy change of a reaction using Hess' Law. The questions covered the requirements of the 2023 assessment specifications to demonstrate understanding of thermochemical principles and the properties of particles and substances.

Commentary

Some candidates confused the electronegativity of an atom with the electronegativity difference in a polar covalent bond.

Many candidates could not distinguish between the entropy change of a system and the entropy change of its surroundings, and did not recognise the significance of the enthalpy change.

Candidates needed to make it clear that intermolecular forces existed between molecules rather than within a molecule. Furthermore, candidates needed to link the strength of temporary dipole forces to the size of the electron cloud.

Grade awarding

Candidates who were awarded **Achievement** commonly:

- drew Lewis structures
- named molecular shapes
- recognised how entropy could increase in the system and/or the surroundings
- identified a factor affecting a periodic trend
- wrote electron configurations using s, p, d notation
- recognised that intermolecular forces exist between molecules
- identified that the presence of hydrogen bonding increases the boiling point of a molecule.

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

- explained the shape or polarity of a molecule
- outlined why vaporisation is an endothermic process
- explained aspects of the entropy changes in the system or surroundings
- explained how some factors affect periodic trends
- calculated an enthalpy change given enthalpy of formation data
- predicted how an enthalpy change would be affected by the change in state of a product
- explained the difference in radii of a metal atom and its cation
- related the strength of hydrogen bonding to the presence of an N–H bond.

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

- explained the shape and polarity of a molecule
- justified the spontaneity of a reaction based on the entropy changes of the system and the surroundings
- justified periodic trends in ionisation energy and atomic radius 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 differences in boiling points by comparing the strength of the intermolecular forces, including linking the strength of temporary dipole attractions to the size of the electron cloud
- used Hess' Law to calculate the enthalpy change of a reaction
- completed calculations with appropriate units and significant figures.

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

- did not name molecular shapes
- did not identify specific intermolecular forces between molecules
- did not recognise exothermic and endothermic processes such as bond making and bond breaking
- did not identify the number of areas of electron density around the central atom of a molecule.

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, and justifying structural formulae based on observations from chemical tests and solubility in water. Question Two covered distinguishing aldehydes and ketones, drawing structural formulae of isomers based on provided information, and condensation and hydrolysis reactions in the context of a dipeptide. Question Three required candidates to name and draw structural formulae of organic molecules, write a balanced equation for the basic hydrolysis of a triglyceride, explain the advantages of heating a reaction under reflux, and draw structural formulae for a series of organic compounds based upon their reactions and the arrangement of the carbon chain. The questions covered the requirements of the 2023 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. Furthermore, many candidates did not understand the difference between a straight chain and a branched chain arrangement of the carbon chain.

Some candidates struggled with questions covering hydrolysis. Candidates needed to focus on splitting the amide or ester linkage, and adding water as –OH and –H.

Practical organic chemistry should be encouraged wherever possible to ensure candidates could recognise appropriate equipment, understand processes such as distillation and heating under reflux, and recall expected observations for chemical tests, including both the initial and final colour of solutions.

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

Grade awarding

Candidates who were awarded **Achievement** commonly:

- named and drew structural formulae of organic molecules
- described expected observations for Tollen’s reagent and/or oxidation of alcohols with acidified potassium permanganate
- used information about a molecule to draw key structural features or functional groups
- drew enantiomers to show a tetrahedral arrangement, and described an asymmetric carbon atom
- completed one step of a reaction pathway, and understood movement of a functional group was required
- identified amino acids from a dipeptide
- recognised that a dipeptide is formed from a condensation reaction between two amino acids
- understood that amine groups are protonated in acidic hydrolysis
- described why heating under reflux is required for a hydrolysis reaction.

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

- completed multiple steps of a reaction pathway
- linked observations from chemical tests to the functional group of a molecule and the type of reaction occurring
- explained a condensation reaction
- drew organic products from acidic hydrolysis of a dipeptide and/or basic hydrolysis of a triglyceride
- explained the advantages of heating under reflux
- interpreted information about an unknown molecule to propose a possible structure and drew additional structures that formed due to subsequent chemical reactions
- understood that organic molecules may have more than one functional group.

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

- understood the properties and reactions of the organic families introduced at Level 3
- completed a reaction pathway with all the required reagents and conditions
- justified the choice of organic molecules based on observations from chemical tests,

functional groups present, and solubility in water

- wrote a balanced equation for the basic hydrolysis of a triglyceride, including structural formulae of organic products
- used information to determine the structural formulae of organic molecules with more than one functional group and the presence of branched chains.

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

- did not start a reaction pathway
- confused the prefixes “prop-” and “pent-”
- did not draw structural formulae from provided information, such as observations from chemical tests, physical properties, and details about the carbon chain
- struggled to link chemical tests to correct observations.

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 at a specified pH, predicting precipitation, and explaining the effect of a common ion and a decrease in pH on solubility. Question Two covered calculating the pH of a buffer, elaborating on how the composition of a buffer can be altered to make it more effective, a weak acid mass calculation, and the properties of pH and electrical conductivity. Question Three was set in the context of a titration curve, and included calculating the pH at and after the equivalence point, explaining how to choose a suitable indicator, and explaining how a buffer functions. All questions required both explanations and calculations to gain Excellence. The questions covered the requirements of the 2023 assessment specifications to demonstrate understanding of equilibrium principles in aqueous systems.

Commentary

Most candidates demonstrated a sound understanding of solubility equilibria. However, some candidates did not recognise the significance of the specified pH on the solubility of lead hydroxide. Candidates were also required to link a change in pH to $[H_3O^+]$ when explaining the effect of pH on solubility.

Calculations were successfully completed by most candidates. This included calculations to determine the ionic product, the pH of a buffer solution, the mass of an acidic salt required to form a solution, the pH of a weak acid solution, and the pH at the equivalence point.

Some candidates did not demonstrate an understanding of the composition and pH of a buffer solution, and how this determined its effectiveness. Some candidates could elaborate on how the composition and pH could be manipulated to form a buffer solution equally effective at neutralising both strong acid and strong base.

Some candidates struggled to explain how to choose a suitable indicator for the titration. Candidates made incorrect statements such as the pH of an indicator determining its suitability for the titration, and often did not state that the indicator needs to change colour. Only those candidates with a thorough understanding linked the colour change and the pK_a of the indicator to the vertical section of the curve / pH at the equivalence point.

Grade awarding

Candidates who were awarded **Achievement** commonly:

- wrote the equilibrium equation and the K_s expression for a saturated solution
- compared the ionic product with the solubility product to predict precipitation

- identified the effect of a common ion on solubility
- calculated the mass of an acidic salt required to make a solution at a specified pH
- recognised that a solution requires ions for electrical conductivity
- calculated the pH of a weak acid
- recognised the presence of a buffer zone approximately halfway to the equivalence point.

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

- used equilibrium principles to explain the effect of a decrease in pH and a common ion on the solubility of a sparing soluble solid
- showed, by calculation, that a precipitate would form when two solutions were added together
- calculated the pH of a buffer solution
- l• inked the degree of dissociation to the concentration of ions in solution to compare the electrical conductivity of two acidic solutions
- calculated the pH at the equivalence point
- explained how a buffer solution functions approximately halfway to the equivalence point.

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

- calculated the solubility of a sparingly soluble solid at a specified pH
- elaborated on how the composition and pH of a buffer solution could be altered to make it equally effective at neutralising both strong acid and base
- justified the pH values of two acidic solutions, based upon the degree of dissociation and the relative $[H_3O^+]$
- explained how to choose a suitable indicator with reference to colour change, the vertical section of the curve / pH at the equivalence point, and the pK_a of the indicator
- calculated the pH after the equivalence point.

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

- did not identify that a decrease in pH will cause an increase in $[H_3O^+]$
- thought a buffer solution is only effective at a pH of 7
- did not identify the pH range over which a buffer will function
- referred only to charged particles, rather than ions, in their description of electrical conductivity
- did not estimate the pH at the equivalence point from the titration curve
- chose an indicator to change colour at the buffer zone rather than the equivalence point.
