Scholarship

2014 Assessment Report

Chemistry

COMMENTARY

This is the second year of the new Scholarship standard where students are expected to show, among other things, a "highly developed knowledge, skills, and understanding (of chemistry that they can apply) to complex situations". Other skills required include the ability to analyse, think critically, integrate and synthesise ideas and present their discussions logically, concisely and clearly. Outstanding students are required to show aspects of perception and insight, sophisticated integration and abstraction, independent reflection and extrapolation, and convincing communication.

It is disappointing to see so many candidates approaching this examination with only a limited understanding of the chemical principles assumed to be part of Level 3 NCEA. Discussions about the reasons for observations, particularly related to periodic trends and intermolecular forces, provide insight into the depth and accuracy of a candidates understanding of atoms, molecules, structure and bonding. Hence it was disappointing that a large number of candidates could not correctly compare the ionisation energies of Na and Mg and showed a limited understanding of ionic and metallic bonding. Candidates appeared more confident in their discussions of intermolecular forces but it is disappointing at this level to see learned responses being given as reasons without checking the appropriateness of the response for the data given. Many candidates were unable to extend their knowledge to more complex situations than that usually provided in Level 3, thus being unable to meet the scholarship standard. It is the ability to think critically and solve problems that require unfamiliar procedures / methods that helps to identify candidates who are working at scholarship level.

In question three, the organic synthesis question, many candidates achieved over 4 marks which showed a much greater understanding of organic chemistry than has been apparent in the examinations over the past couple of years. There were fewer papers where this question was not attempted than in past years and for the most part candidates could identify the compounds A to H but often made errors at the end of the cycle or struggled to identify reagent X. There was a lack of consistency in the form of organic structures used in answers and candidates should be encouraged to use the form of structures that are given in the question. There is also a need for more care when drawing organic structures to make sure that bonds link to the correct atoms.

There was little evidence of 'planned' answers where discussions were required. Often students seemed to write all they knew, for example about intermolecular forces and did not relate this knowledge to the specifics of the graph/data given in the question.

The lack of equations in chemistry discussions is also a concern. When reactants and products or 'left hand side and right hand side' of an equilibrium reaction are discussed it is expected that an equation would also be present. Similarly, when calculating E° for a 'cell' there must be a link to the cell and this is usually through a chemical equation. Candidates should be encouraged to add annotated diagrams to their discussions as this can lead to more concise explanations, for example, when describing hydrogen bonds.

It was disappointing that few candidates were able to carry out the titration calculation. Dilution factors seemed to confuse many of them, the wrong molar mass was often used - $M(OCl^-)$ rather than $M(NaOCl)$. Too often it was difficult to follow the answers to calculations due to the lack of organised working being shown.

The calculation and interpretation of the experimental procedure in question five proved challenging to all but the most able candidates. However, it was disappointing that only a small number of candidates recognised and applied equilibrium principles to correctly interpret the data provided in Part A.

SCHOLARSHIP WITH OUTSTANDING PERFORMANCE

Candidates who were awarded Scholarship with Outstanding Performance typically:

- wrote logical, coherent answers that linked to the data given
- integrated equations, symbols and diagrams into their answers, where appropriate
- extrapolated from their Level 3 knowledge to provide explanations for phenomena/ observations
- showed perception and insight in their interpretation of data
- wrote a logical account of the differences between magnesium and sodium for each step in the Hess's Law cycle linking these to the overall enthalpy of formation
- showed a highly developed understanding of atomic structure and bonding including ionic and metallic bonding and ionisation energies
- compared the stability of MgCl with $MgCl_2$ by calculating the enthalpy of formation for MgCl and contrasting the answer to $\Delta_f H(MgCl_2)$
- critically analysed the misconception about energy stored in the bonds of glucose and provided a correct account of the energy changes linked to the process of bond making and breaking
- showed a highly developed understanding of entropy and enthalpy changes and applied these to the context given
- calculated the concentration of the bleach correctly and used this to determine the extent of decomposition using the units required
- showed a highly developed understanding of electrolytic processes and gave a logical account of the oxidation-reduction processes involved that included calculations (of cell potentials), balanced equations and a discussion of the relative oxidising and reducing strengths of the species present
- showed a highly developed understanding of intermolecular forces by linking the data in the graph with the nature of the molecules involved including reasons for observed trends in dipole-dipole and induced dipole-induced dipole forces
- extrapolated ideas about intermolecular forces to explain "unexpected" data in the graph, for example; CO and Ar having the same overall force, H_2O forces being much stronger than NH_3, the relative sizes of the induced dipole-induced dipole forces in HCl as well as NH_3 and H_2O
- wrote concise, well-constructed discussions that were not repetitive and used diagrams where appropriate
- utilised the concept of chemical equilibria using this to account for the changes in the concentration of the species (OH^-, PO_4^{3-} and F^-) present in the environment surrounding the tooth as the pH changed
- extrapolated to show a highly developed understanding of knowledge of both solubility and solubility products to compare the solubilities of the two apatites, including writing K_s expressions and relevant equations
- showed a highly developed understanding of acid and base concepts by correctly calculating pK_a from the data given and linking the answer to acid/base strength and the information given
- interpreted the data provided for the analysis of strontium ions by writing appropriate equations, recognising the conditions needed to provide the ions and conditions needed for precipitation, recognising the nature of the buffer within the solution in their calculations and identifying the role of the indicator in the process.

SCHOLARSHIP

Candidates who were awarded Scholarship but not Scholarship with Outstanding Performance typically:

- wrote discussions that accurately represented chemistry ideas
- provided organised and coherent answers
- linked answers to the data / information given
- wrote an account for some of the differences between magnesium and sodium in the Hess's Law cycle including a correct discussion of the strength of metallic bonds, ionic bonds and ionisation energies
- calculated the enthalpy of formation of MgCl and compared the answer to $\Delta_f H(MgCl_2)$
- accounted for the entropy and enthalpy of at least one of the processes linked to balanced equations and energy calculations
- identified the misconception about energy stored in bonds and gave a correct interpretation of the evidence linked to bond making and breaking
- used the titration data to calculate the concentration of the bleach and used this to find the concentration of available chlorine or percentage decomposition using the mass of sodium hypochlorite
- wrote equations for cell reactions and correctly calculated and interpreted cell potentials with either a discussion of the oxidation-reduction processes involved or the relative oxidising and reducing abilities of the species available
- accounted for the differences in intermolecular forces by describing the types of forces and giving reasons for the differences related to the nature of the molecules used in the graph
- linked the data in the table to periodic trends in atomic size and electronegativity, including hydrogen bonding as a dipole-dipole force and recognising the reasons for the different strengths of hydrogen bonds
- discussed observations using equilibrium principles including equations for the dissolving and precipitation reactions
- recognised how changes in pH affected the concentration of some of the species present (OH^-, PO_4^{3-} and F^-) and the consequent effect on solubility
- calculated pK_a from the data given and linked this to the strength of the conjugate base
- recognised in a discussion the role of OH^- in the conversion of $H_2PO_4^-$ to HPO_4^{2-} and included relevant equations
- showed understanding of some of the steps needed to calculate the concentration of strontium ions including the role of the indicator.

OTHER CANDIDATES

Candidates who were not awarded Scholarship or Scholarship with Outstanding Performance typically:

- often wrote incomplete answers that lacked coherency and showed limited or incorrect understanding of the chemical principles involved
- used arguments about stability of filled and half-filled shells to compare ionisation energy / stability of Mg and Na atoms or omitted important points in the comparison of ionisation energies, e.g. energy level of valence electrons
- did not understand the factors affecting the strength of ionic and metallic bonds
- attempted to compare the stability of $MgCl_2$ and MgCl without undertaking the appropriate calculation

- did not recognise the link between bond breaking and bond making, and energy changes within reactions
- could not calculate the enthalpy changes for the photosynthesis / respiration reactions
- showed a lack of understanding of entropy and used incorrect terms, such as combustion, catalyst, activation energy, in discussions of respiration and photosynthesis reactions, or attempted to use biology concepts in discussions
- included the non-concordant titre in the titration calculation
- made errors in the calculation, including using the wrong molar mass (for OCl^- instead of NaOCl), incorrect dilution factors and showed a poor understanding of how to calculate percentages
- were unable to identify species present in electrolytic processes or discuss the oxidation / reduction processes
- did not include equations for cell reactions or calculate and interpret electrode potentials for redox equations
- did not recognise the functional group needed to bring about the substitution reaction in the organic synthesis
- did not take care in drawing organic structures resulting in some of the answers being ambiguous
- did not provide a coherent, organised account of the similarities, differences and trends in the graph provided. This included not linking the graph to the different types of intermolecular forces, made generalisations about intermolecular forces that contradicted the data given, e.g. "dipole-dipole forces are stronger than induced dipole-induced dipole", using the term electronegativity incorrectly, discussing hydrogen bonds without linking them to the graph, using terms which were not in the given graph, such as London / dispersion / van der Waals / temporary / permanent dipoles without defining them, and only considering molar mass not the size of the electron cloud for the trends in induced dipole forces
- discussed only electronegativity difference when comparing the strength of the hydrogen bond and ignoring the size of the N and O atoms
- discussed the trends in the graph without any reference to the nature of the intermolecular forces or reasons for the differences
- attempted to discuss chemical equilibria – (system moving to favour products / reactants) without providing any equations for the reaction, or used the term "Le Chatelier's principle" without saying what this term meant
- limited their discussion to only one reaction species in the tooth environment in spite of data being given for phosphate, fluoride and pH.
- showed limited understanding of equilibrium systems, solubility and solubility products
- did not link the concentrations of hydronium and hydroxide ions, and pH or use the correct expression for the K_a of water
- did not provide sufficient links in discussing the relative strength of conjugate bases using pK_a data
- did not relate the steps in the gravimetric analysis procedure to the chemical reactions occurring, assuming that, because an indicator was used a titration was involved
- did not recognise a buffer solution formed when both $H_2PO_4^-$ and HPO_4^{2-} were present – hence a calculation for an acid was carried out rather than for a buffer
- did not recognise the role of the indicator to show the pH of the solution, so discussed the need for an indicator that "changed colour close to the equivalence point".