NEW ZEALAND QUALIFICATIONS AUTHORITY
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Scholarship, 2006

Chemistry

Assessment Report

Chemistry, Scholarship, 2006

Commentary:

It was a requirement of the 2006 examination that all questions would be worth 8 marks and that the maximum number of questions allowed was 6. Some topics were emphasised more than others because the content at level 3 includes 4 externally assessed standards and two practical standards. The 'write-on' nature of the examination gave a guide as to the amount of writing / working expected for each answer.

The best performing candidates most commonly demonstrated the following skills and/or knowledge:

- wrote logical and coherent responses and showed some evidence of planning and linked their knowledge of chemistry directly to the context of the question asked
- correctly used chemical vocabulary and defined terms when necessary
- read and interpreted questions correctly
- wrote answers that were supported by balanced equations and / or correct formulae
- presented accurate calculations, showed working clearly and used significant figures appropriately
- showed an accurate and detailed understanding of chemical concepts especially in answers relating to atomic properties and intermolecular forces
- showed some evidence of practical laboratory work and an understanding of the procedures used
- applied their knowledge in unfamiliar settings, particularly in the question where electrode potentials were used to inform the reactions in an electrolytic cell
- were familiar with all the Level 3 and related Level 2 Achievement Standards

Candidates who did NOT achieve scholarship lacked some or all of the skills and knowledge above and in addition they:

- were unprepared for the lack of scaffolding in the questions and misunderstood what was required from the questions and the data that was given
- were unable to organize their time to attempt all the questions
- appeared to have large gaps in their Year 13 Chemistry and left out all questions on one topic e.g. organic chemistry, aqueous chemistry or calculations related to an investigation
- showed misconceptions in their understanding of chemical principles in explanations as shown through their discussions about atomic properties and about intermolecular forces
- stated facts without linking them to the question asked
- used chemical jargon without explaining the meaning of the words so it was not apparent that they understood the underlying concepts e.g. van der Waals forces, effective nuclear charge
- used 'remembered formulae' for pH calculations incorrectly rather than developing these from first principles
- stated facts about what they knew but did not link these to the question asked
- did not explain their ideas clearly
- misunderstood chemical ideas eg
    - $\Delta_{fus}H°$ in question 1. This was confused with heat of formation or believed that this is a change from (s) → (aq)
    - stability and orbitals in Question 2
    - assumed that CH_3NH_3Cl produces HCl and so has a low pH
    - used standard electrode potentials inappropriately eg stated that the oxidant (question 5) is H_2O/O_2 or that IO_3^-/IO^- disproportionates
- misunderstood the reasons for practical techniques eg swirling
- miused phrases such as van der Waals and 'like dissolves like'

Comments about candidate performance in individual questions:

The best performing candidates most commonly demonstrated the following skills and / or knowledge:

1(a)
- recognised the relationship between the data given and the nature of the forces between the particles in each substance
- accurately discussed the particles and the nature of the forces between them for each substance
- related the difference between $\Delta_{fus}H^{o}$ and $\Delta_{vap}H^{o}$ to the energy differences in particles in solid, liquid and gas phases particularly in relation to movement and separation of particles

1(b)
- applied Hess's Law by writing equations for the thermochemical data provided and manipulated them to give the energy change for the given reaction
- recognised the spontaneity of reactions with respect to the sign of ΔH .

2(a)
- related the increasing trend in ionization enthalpy to distance of e^{-} being removed from the nucleus as determined by the shell/energy level in which it is found and the effect of repulsion between the e^{-}s in the shell/energy level
- related the similarity of Mg and Na to the similarity of their e^{-} arrangements ie. valence e^{-} in same shell/in same row of periodic table
- related difference of Mg and Na to the difference in the size of the nuclear charge

2(b)
- deduced the appropriate structures of up to 4 esters that meet the requirements given for Compound A
- identified the related structures for Compound B that could be long chain alcohols or carboxylic acid
- justified their choice by discussing the polarity of Compounds B

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- identified appropriate reagents and conditions ie. those that would not produce conflicting reactions
- recognised the possibility of a minor product from the addition reaction and organic by-products of other reactions
- discussed the necessary order of reactions in relation to the expected products

4(a)
- discussed the hydrolysis reactions of the given substances and wrote equations to support the change to the pH from that of pure water
- recognised the buffer nature of Solution C from the presence of equimolar solutions of both the base and its conjugate acid and the consequent pH = pK_a (10.6)

4(b)
- identified the change in the concentration of the appropriate base and acid present after the initial reaction
- used the K_a expression to calculate pH

4(c)
- discussed changes in the solubility of $Cu(OH)_2$ in relation to the solubility equilibrium
- Identified change in Cu^{2+} from the formation of a complex ion with the amine and and OH^{-} due neutralization by the acid
- wrote balanced equations for the reactions occurring

4(d)
- used the K_s formula correctly to calculate the maximum value of $[OH^{-}]$ possible
- used the K_a expression to calculate $[CH_3NH_3^{+}]$ and hence the mass of CH_3NH_3Cl

5(a)
- recognised that this is an electrolytic cell and hence energy is supplied to the reaction
- identified the species present in the electrolyte and used the data to deduce the strongest oxidant and reductant among these species
- used E° values to validate processes
- described actual observations (colours, appearance of substances) for changes that would occur

5(b)
- identified the meaning of disproportionation from the supplied information
- carried out appropriate calculations to identify which species will disproportionate
- wrote balanced equations for the specified basic conditions

6(a)
- processed the data given and discussed the species affected by the actions described

- related possible changes in iodine concentration to the titre value of thiosulfate and hence the calculated Vitamin C concentration (recognising that a back titration was carried out)
- recognised that the formation of I_3^- was an equilibrium process and hence reversible as the concentration of reactants changed

6(b)
- set out calculations clearly, showing the species each value in the calculation refers to
- used appropriate significant figures
- showed logical and coherent reasoning
- identified the small volume of thiosulfate as leading to a high percentage error

Candidates who did NOT achieve scholarship commonly lacked all or some of the skills and knowledge above and, in addition, they:

1(a)
- confused $\Delta_{fus}H$ and $\Delta_f H$
- did not accurately describe the nature of the bonding and the particles present
- were unfamiliar with the nature of ionic bonding
- implied that molecules are broken apart in a change of state
- were unfamiliar with or did not describe differences in the energy and separation of particles in different phases

1(b)
- were unable to use the thermochemical data given to write the related equations and hence apply Hess's Law to calculate the ΔH for the required process
- did not know the significance of the sign of ΔH with respect to spontaneity of reaction

2(a)
- did not recognise that the energy needed to remove each successive electron depended on the distance of the electron from the nucleus. This distance is dependent on the energy level in which the electron is found (distance of energy level from the nucleus and shielding from inner electrons) and the number of electrons in the shell (more electrons have greater repulsive forces so are further from the nucleus)
- focused on stability of electron arrangements to explain the variation e.g. stating that it is harder to remove an e^- from Mg^{2+} than Mg^+ because Mg^{2+} is more stable than Mg^+.
- assumed that the nucleus had greater attraction for electrons when it was attracting fewer of them

2(b)
- did not:
  - justify their choice of Compounds A or B
  - draw structures but relied on naming that was often incorrect
  - justify the non-polarity of Compound B
  - identify the structures they drew as compound A or B

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- did not identify reactions that would occur simultaneously e.g. oxidation of primary and secondary alcohols
- did not identify competing reactions
- did not identify Markovnikov products of addition reaction of water
- did not realise that product of addition reaction was a tertiary alcohol and therefore would not be oxidized
- did not identify organic by-products of reactions

4(a)
- identified predominant species (with respect to pH) present, but did not relate this to pH
- did not identify Solution C as a buffer solution with equal concentrations of acid and conjugate base or…
- thought that a buffer solution was neutral

4(b)
- did not:
  - identify the species present after addition of HCl and hence their concentrations
  - identify the new volume of the solution
  - use K_a expression to calculate the $[H_3O^+]$, often using a learned version of pH =

… incorrectly

4(c)
- did not:
  - o write equations for processes occurring
  - o identify acid-base reaction for solution B
- thought that a base would cause dissolving because "like dissolves like" or common ion effect
- wrote the complex ion using ammonia instead of the amine

4(d)
- incorrectly used K_s expression to calculate $[OH^-]$ by not substituting in the value of $[Mg^{2+}]$.
- did not calculate
  - o the $[H_3O^+]$ from $[OH^-]$
  - o the mass of CH_3NH_3Cl
- did not use K_a expression to calculate the [HA]

5(a)
- did not:
  - o recognise that the process occurring is electrolysis
  - o identify the species present in the solution
  - o describe the appearance of any species formed
  - o write equations for reactions occurring at the electrodes

5(b)
- did not:
  - o use the supplied information to correctly identify what auto oxidation-reduction was in respect to what the reactants were
  - o comment on the sign and size of the calculated cell potential
  - o write balanced half equations and full equations
  - o recognise the basic conditions

6(a)
- used iodine and iodide interchangeably
- did not:
  - o recognise the I_3^- equation as being an equilibrium and therefore reversible
  - o use the supplied information on the properties of iodine to deduce the effects of each action
  - o recognise the back titration
  - o comment on the effect on the concentration of vitamin C

6(b)
- did not:
  - o recognise the back titration
  - o set out calculations logically or clearly
  - o write ratios for reacting species