Scholarship

2013 Assessment Report

Chemistry

COMMENTARY

This is the first year for the new Scholarship Chemistry Performance Standard. The new standard expects students to use and apply their chemistry knowledge to demonstrate that they have developed the ability to analyse, think critically, integrate and synthesise ideas, and present their discussions logically, concisely and clearly. In addition, outstanding students are required to demonstrate aspects of perception and insight, sophisticated integration and abstraction, independent reflection and extrapolation, and convincing communication. This has meant some changes either to the nature of the questions asked or to the emphasis in the judgement statements to accommodate these skills.

For example, in question one (a)(i) data was provided about single and double bonds but the question also asked about triple bonds and students needed to recognise the trend and extrapolate to suggest reasons for the non-existence of tripled bonded silynes. Similarly in question one (b) the question required calculations for both standard and non-standard states and the significance of the calculations evaluated in the light of the observed structures. Question one (b) required students to link the measurements of mass % of the composition of ionic compounds, to electron configuration linked to atomic / ionic size, which is used to account for the differences in melting points. Students who planned their answers to show these connections in a logical and concise way were able to demonstrate the communication skills required by the performance standard. Concise, clear and logical communication is evident when answers are well ordered and not repetitive. So if something similar is used to explain a number of different factors it is not rewritten each time but well set out the first time and then referred to as appropriate. This was evident in the best answers for question two (b) and question three. In chemistry, convincing communication could be by way of well documented calculations which are linked back to the problem to be solved. It could also be enhanced by the use of annotated diagrams. For example, in question four (c)(ii) the calculations needed to be linked to the de-oxygenation of haemoglobin. Students at this level should expect to be provided with data or information to analyse and to integrate into their existing knowledge in order to solve the problems or answer the questions.

There was evidence of poor time management by some candidates, who left question parts unanswered. Candidates who utilise effective examination technique recognise that questions do not need to be answered in the order that they are given and also are careful not to spend too long on any one question. Questions are designed to be answered in 30 to 35 minutes so if it is taking longer than this, it maybe that too much detail is being given in the answer or that the candidate lacks confidence in their knowledge and would be better to move onto another question.

Candidates' communication skills would be enhanced by providing labels for reactions and diagrams and referring back to these in discussions. When data is provided it is usually expected that it will be used to answer a question so candidates must link their answers back to the data. For example, in question one (a)(i) the data provided needed to be referenced in the answer. The information provided about the difference in the strength of the two bonds in a double bond, and if the data was used in calculations usually led candidates to the answer about the triple-bonded species. Communication using the correct chemical terminology was an issue for many candidates, particularly regarding particles, substances, and the intermolecular forces. Candidates at this level are expected to show an in-depth understanding of forces between molecules and it is disappointing to find many referring to hydrogen bonds within molecules or using the general term "van der Waals" forces rather than distinguishing the forces in action.

Careful reading of questions is also important. In question one (b) it stated that the compounds of indium were ionic but many candidates discussed covalent bonding in their answer.

In question one (b) it was noted that candidates who wrote out the electron configuration of indium first, usually wrote correct configurations for ions but those who tried to go directly to the ion configurations usually got them wrong. There was evidence that the block structure of the periodic table was not well understood so it was not recognised that indium falls in *p*-block and therefore has its valence electrons in a *p*-orbital. Many candidates went to 4*f*.

The question about the electrolytic cell was not attempted by many candidates, and was poorly answered overall. The use of electrode potentials to determine the spontaneity of a redox reaction linked to appropriate balanced equations is required for the internal achievement standard 91393, and so is part of the knowledge base required for scholarship chemistry. However many candidates did not show the requisite understanding.

For organic reaction schemes it is expected that structural formulae will be used and the scheme annotated to show the conditions for the reactions. Line diagrams are acceptable but certainly not required at this level. They were introduced in question three as an alternative way of writing the structures for the large molecules but not required for the answer. It was expected that candidates at this level would be familiar enough with the reactions of acyl chlorides and haloalkanes to know that the acyl chlorides would be the more reactive of the two.

A number of candidates are competent at carrying out complicated calculations but are unable to relate the calculations to the chemistry involved. This was apparent in the calculations relating to the pH of solutions, particularly of buffer solutions. Candidates showed little understanding of the significance of pK_a.

At this level questions will not usually ask for balanced equations. However, any discussion of chemical reactions should be supported by correct formulae and/or balanced equations. This was important for the discussion of the chemistry of the reactions in question five. The lack of familiarity of H_2O_2 as an oxidant was a concern. Many candidates were able to carry out the titration calculations required in question five. However, they did not read the question carefully and failed to take into account that the amount of sulfur present was distributed among the four different samples so taking an average would not provide the correct answer. Answers about the environmental impact were often vague and failed to outline the nature of the reactions involved.

SCHOLARSHIP WITH OUTSTANDING PERFORMANCE

Candidates who were awarded Scholarship with Outstanding Performance typically:

- showed evidence of insight and extrapolation; taking the information given in a question and integrating it with their own knowledge of chemistry
- communicated their answers clearly; provided coherent and relevant discussions which integrated chemistry symbols and conventions into their answers
- integrated ideas to demonstrate understanding; linked the macroscopic, the sub-microscopic and the symbolic
- showed evidence of planning to produce coherent and relevant answers
- recognised the relationship between the reactivity of a compound and bond strength

- distinguished a double bond to be made up of two different bonds of different strengths and therefore were able to compare the stability of two different double bonds
- used data provided to support their explanations or discussion
- recognised that to ‘compare and contrast’ required them to calculate both discrete and lattice enthalpies of formation for both compounds and that the significance of the results was linked to the observed physical properties
- showed working for calculations in a way that was easy to follow and included units
- recognised and discussed the factors which affected the strength of an ionic bond linked to the electron configuration determined from the mass % of the compound
- recognised the need to provide balanced equations for the electrochemical cells which were then used to determine the cell potential and linked to the energy requirements of the cell
- provided a coherent and concise discussion of the dissolving process for molecular and ionic compounds by considering the changes occurring at particle level often including annotated diagrams
- applied their understanding of the properties of mixtures to the way they are used
- provided clear, concise pathways for the conversion of putrescine to spermine using the organic molecules provided, including organic structural formulae
- showed similarities and differences in the pathways without repeating the same steps each time
- calculated the pH of a buffer after a change was imposed on it
- linked pK_a to the strength of a base
- demonstrated an understanding of percentage dissociation of an acid and linked calculations to the species present in solution
- discussed how buffers maintain the pH of a system
- used all the data provided to carry out the calculations (for % purity of sulfur) and related the information given to the accuracy of the data collected.

SCHOLARSHIP

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

- wrote discussions that were well organised and coherent but not always concise
- used data to support statements
- compared and contrasted discrete and lattice formation for SiO_2 and CO_2 but did not recognise the need to carry out calculations for all four structures correctly, yet completed most of the calculations
- linked ionic bond strength to the charge or size of the ion
- identified species being oxidised and reduced within electrochemical cells
- discussed interactions of polar, non-polar and ionic substances during dissolution linking the process to the structures of the compounds involved
- recognised most of the steps needed for the organic pathway particularly the two-step conversion of an alcohol to an amine or the reduction of an amide to an amine
- used structural formulae to draw their organic reaction schemes
- linked their reaction schemes to their explanation for compound A being the best reagent for the synthesis
- calculated the pH of the buffer solutions and/or the ratio of species in a buffer at a given pH

- used the portion of the titration curve provided to provide information about the carbonic acid-hydrogencarbonate buffer system in blood
- discussed how a change in concentration of one species would impact on the position of an equilibrium
- recognised the types of reactions occurring in the analysis of sulfur described in question five and used balanced chemical equations to support their discussion
- used all the data provided for the analysis and commented on the differences
- set out calculations clearly and used appropriate units at each step
- recognised the reasons for the steps taken in the analytical procedure
- linked the outcomes of the experiment to environmental implications with an appropriate discussion of the chemistry involved including balanced equations.

OTHER CANDIDATES

Candidates who were not awarded Scholarship typically:

- recognised that reactivity of a compound can be related to bond strength but did not link this to the data given or the compounds in the question
- used inappropriate formulae for example, to calculate enthalpy of formation they only considered bond formation or used $\Sigma\Delta_f H°$(products) – $\Sigma\Delta_f H°$(reactants)
- did not link observation of physical properties to structures
- calculated the correct ratio (In : S) but could not use this to find the formula of the compound
- discussed temporary and permanent dipoles in the indium sulfide compounds as they did not notice that it stated that the compounds were ionic
- were unable to use the given electrode potentials to determine the species involved in electrochemical cell or the spontaneity of the cell
- did not recognise that electrolysis requires energy and has a negative cell potential
- showed little understanding of forces between molecules and/or used incorrect terminology to describe particles and the forces between them
- used incorrect, unclear, or generic terms or phrases; such as "van der Waals", "like-dissolves-like"
- put reactions into the organic schemes that would not work, e.g. substitution of -OH with $–NH_2$ or the combination of two amines
- did not recognise that polymerisation reactions will occur when there are two of the same functional groups at each end of a molecule
- did not recognise pH = pK_a half way to equivalence point
- provided a very limited discussion of the effect of changing condition on equilibrium processes
- did not recognise the different types of reactions described in the analysis of sulfur – usually combustion and precipitation were recognised but not oxidation-reduction.