

## Feedback on Questions

### Question 1

This question arose out of the recent news report concerning the leak of potassium manganate(VII) into the water supply in the Canadian town of Onoway. We often like to take examples of Chemistry from the press and investigate whether the science behind the scare stories is justified! The key skills tested in this question were some simple inorganic chemistry and balancing equations, the accurate and consistent application of oxidation numbers, and the understanding of units and their conversion.

#### Section I

Parts (a) and (b) were generally answered well, but some candidates suggested that the maximum oxidation number of manganese might be 25, as the neutral atom contains 25 electrons! More commonly, reference was not made to the data supplied to justify the correct answer of +7.

The dot and cross diagram was often not well done (or indeed well-marked by the teachers!). We credited anything that was chemically feasible and correct: dative bonds from Mn to O are fine but care must always be taken to ensure that period 2 atoms (O in this case) do not exceed their octet. The 'extra' electron should be placed on an O rather than the Mn centre, but fully delocalised structures would have been fine.

Parts (d) through (f) concerned the balancing of equations of various kinds and, as ever, candidates find this a difficult skill. The main errors noted by the examiners were (e)(ii): using  $\text{Mn}^{6+} / \text{Mn}^{7+}$  instead of the compound ions, not including water in the disproportionation reaction and including  $\text{H}^+$  ions in equations for reactions that generate  $\text{OH}^-$  ions.

#### Section II

The units acceptable for part (g) were any that were dimensionally correct, including  $\text{dm}^3 \text{mol}^{-1} \text{cm}^{-1}$  or equivalent. However, candidates should note that they will find that this is the only common one used in universities, because the cuvette path length is almost invariably measured in cm!

Most candidates were able to calculate the molar absorptivity from the graph but had some difficulties converting concentrations into  $\text{mg dm}^{-3}$ . Many teachers marked part (h) wrong if the units used were not those given in the mark scheme. This was corrected when we moderated the Rg scripts. The answer to (j)(ii), although the data given in the question was an estimate on our part, seemed to suggest that a resident of Onoway would need to drink a vast quantity of tap water (about  $2600 \text{ dm}^3$ !) to be troubled by the  $\text{KMnO}_4$ .

#### Section III

Part (k) was generally answered well but more struggled with the Hess cycle in part (l). Those who have been trained always to apply 'Products minus Reactants' found, of course, that this rule is not generally applicable, and should not be learned! It is important to note that the standard enthalpy change for a reaction depends upon the molar quantities given in the balanced equation. We specified that the equation should represent the decomposition of **one mole** of compound X. Many candidates wrote the equation using two moles of X and therefore lost marks.

Parts (m) and (n) were very demanding and only the best candidates successfully answered them. In (m) the combination of the percentage yield with the percentage excess reagent caused problems. It was common in part (n) for candidates to use the ratio of masses rather than the ratio of moles. It

should be said that we should have specified whether the concentration of sodium permanganate was 40 % w/w or w/v. This did not seem to cause any candidates a problem; they assumed that w/v was what was meant, as indeed did we!

Although we don't require working to be given in the answer booklet, and always award full credit for the correct answer, it is difficult to award partial marks if the working is absent or not clear.

## Question 2

We chose the subject matter for this question knowing that bromination of alkanes is one of the first organic reactions encountered in year 12. We felt that candidates would find it interesting that even simple halogenoalkanes are used in the synthesis of important pharmaceuticals.

Part (a) should have been familiar to all candidates however the classification of the first reaction was not always answered correctly.

Parts (b) and (c) needed candidates to appreciate two things: symmetry and the fact that equivalent positions within the molecule are more likely to be substituted if there are more hydrogens attached, purely on the basis of probability. Candidates found this quite demanding although the best coped admirably with these new concepts. Combining this idea with the observed percentages of different products to produce a measure of relative reactivity in part (d) was particularly demanding.

In part (e), the molecules were designed to be more difficult; seeing molecules in three dimensions is a crucial skill for a chemist and one that requires much practice. If students could be given the chance to make models of compounds then these ideas would become clearer. Part (f)(i) was the hardest example of this thinking and significant credit was given for correct answers. Part (f)(ii) required the recognition that tertiary carbons are the most easily substituted in this reaction.

Part (g) tested the important skills of reading and understanding! Application of novel ideas is a general feature of questions at this level and is much prized by universities. Part (h) on the other hand is straightforward and many candidates completed this easily but part (i) required the application and extension of the ideas encountered in (b) and (c).

Part (j) was an homage to the very first C3L6 question that we set and was a reminder that candidates who took the trouble to look over past papers were at an advantage.

As with previous organic synthesis questions, we wanted candidates to understand the importance of maintaining a carbon framework rather than introducing random changes. Indeed, this year we explicitly asked candidates to trace atoms in the product back to the starting materials.

Part (m) was designed to be the most challenging section of the paper but even so, the best candidates managed to complete all of it. If candidates had looked at past C3L6 (or indeed Olympiad Round 1) papers, they might have picked up on the important synthetic route that involves the loss of  $H^+$  from a carbon that is adjacent to certain electron-withdrawing groups such as  $C=O$  or  $C\equiv N$ . In addition, a number of the key reactions on the final page of the paper were nucleophilic substitutions, which should be familiar to all Year 12 chemists.