Feedback on Questions

This year is the International Year of the Periodic Table and we themed our paper accordingly. Question 1 was inspired by the history of the periodic table. In particular we wanted to show how errors in atomic masses led to elements being misplaced. Question two explores the properties of periodic acid, and we apologise for the rather paw pun! We would like to thank teachers who sent in pictures of their cats in response to this question.

Question 1

This question was split into several sections testing different parts of the A-level syllabus. Each section was structured to begin with A-level material and we were pleased to see that many students solved these parts. We also included concepts taught in A-level in a non-standard format and some very challenging sections that were answered well by the gold- and roentgenium-level students.

Section I

Many students answered 1 (a) parts (i) to (vi) correctly, showing a good understanding of redox reactions and balancing equations. We were happy to accept equations including ions, or anything that was chemically sensible. Part (vii) asked students to calculate the mass of indium oxide formed from 1g of metal. Few students attempted this part, but those who did have a go generally answered the question well. Similarly, in section (b) many students found it difficult to convert the question from words into the algebra needed for the calculation.

Section II

As expected, the majority of students could do section (c); common errors included giving fractional numbers of neutrons or the electron number of iodine rather than the iodide ion. Section (d) was one of the most challenging on the paper. Again we feel that an algebraic method was the best way to solve this problem. Those who structured their answers clearly were often rewarded with partial marks.

Section III

A relatively small number of students recognized that the reaction in section (e) was a redox process, and hence attempted to balance the equation without including molecular iodine. We were surprised to see that very few students gave the correct oxidation state of +1 for Cs in CsI_3. We had hoped that the structure of the question, describing the propensity of Tl to form the +1 oxidation state and referring to the average oxidation state of iodine in part (ii), would give a hint that these compounds included the I_3^- ion. There are no compounds with Cs in an oxidation state other than +1! Surprisingly some students drew a correct dot and cross diagram for I_3^- despite getting the oxidation state for Cs incorrect.

Section IV

In section IV many students were able to make the connection between nitrogen and niobium chemistry to correctly answer parts (i) to (iii). Part (iv) was based on the familiar Hess cycle, but for a more complicated system than encountered at A-level. Few students got the correct answer, but again those who drew out the cycle carefully were often rewarded with partial marks. Part (v) was also very challenging, the 1:1 ratio in the reaction between lithium hydroxide and nitric(v) acid leads to the formula $LiNbO_3$, whilst the 1:3 ratio with phosphoric acid leads to Li_3NbO_4, the analogous compounds being $LiNO_3$ and Li_3PO_4. It was clear when marking that students did not know the formula for phosphoric(V) acid.

Section V

The aim of this section was to draw out the relation between the number of electrons in the valence shell and the maximum oxidation state. This was done well by the majority of candidates. We were also pleased to see that many students were capable of giving the full electron configuration for oganesson, however some students struggled to correctly number the f-orbitals. Only the very strongest candidates could predict the patterns in electron configuration towards the end of the (current) periodic table.

Question 2

The aim of this question was to introduce a new chemical concept and test the students' ability to apply this new information to a range of unfamiliar situations.

Section (a) on the high oxidation state iodine acids elicited some fine answers and we were impressed with students' ability to think about unfamiliar compounds. By contrast, very few students identified periodic acid as an oxidizing agent; students most commonly described it as a dehydrating agent due to the production of water during the reaction. Section (c) asked students to predict some reaction products. They found both the reaction of cyclic compounds and multiple reactions on an acyclic species challenging. In an earlier draft we had included some simpler compounds here, and on reflection we should have left these in to guide candidates. We were surprised at the variety of cyclic structures given for section (d); candidates did not focus on the fact that both oxygen atoms in the diol needed to be bonded to iodine. To introduce students to the idea that periodic acid can also react with carbonyl compounds we illustrated the general reaction before section (e). Many students gave correct structures for the hydrate, but then were unable to follow through to the cleavage compound. Sections (f) and (g) followed on from (e), and therefore errors in understanding rapidly became magnified. The students were given all of the information needed for question 2 (e) – (g) in the preamble. Careful application of the basic principle of simultaneous oxidation and cleavage of 1,2-diols should have led candidates to the correct answers.

Sections (h) and (j) were designed to stretch the top end of the cohort and did so successfully. However we did see a handful of correct solutions, which was very gratifying, and this demonstrates an excellent understanding of the chemistry we had introduced in the question.

There was perhaps more text in this paper than previous years and it was clear that some candidates ran out of time. However, it was really pleasing to see an outstanding top score of 62 out of 64, and that every part of every question had someone answering it correctly.