REPORT ON THE CHEMISTRY OLYMPIAD ROUND 1 PAPER 2006

In past years the committee was prepared to mark only a maximum of five entries per school for consideration for certificates, but this year we also gave schools the alternative of entering more than five candidates for the competition so long as they pre-marked all of their entries. This seems to have been popular since the number of entries went up considerably. The number of schools taking part increased by 50 to almost 280, and the number of scripts received rose by nearly 500 to almost 1400. This is very encouraging (although we are slightly puzzled that about 70 schools registered but did not take part).

All high-scoring scripts were remarked by the committee: the marks were changed only slightly at this stage, and this suggests that supplying a detailed mark-scheme to teachers is an experiment which we should continue with in future. The very helpful and largely positive comments that we have received on this year's Olympiad paper suggest that we have again managed to set a paper which is both relevant and challenging to sixth form students and much appreciated by teachers. The most common criticism was that the paper was too long rather than impossibly difficult. Although we use the results of this test to select the students who proceed to Round 2 and eventually into the UK Chemistry Olympiad team we hope that it does more than that: it should promote Chemistry as a relevant and exciting subject and stretch the most able students in the sixth form who may find A levels not sufficiently demanding.

It was certainly a demanding paper but there was a good distribution of marks: almost 5% of candidates were awarded a gold certificate for scoring more than 54 marks out of 78, 17% got silver certificates for between 43 - 53 marks, and 24% got bronze certificates for marks between 33 - 42. There were many other creditable performances outside of this range, and only a very small number of candidates (2%) who failed to score double figures.

An encouraging number of scripts were received from students in the lower sixth: the top mark for a lower sixth student was 65/78! This was very impressive since presumably these candidates may have only been studying A-level Chemistry for a term and a half. We want to encourage even more entries from talented Lower Sixth applicants in the future. To help this we are hoping to invite the best performers in the Lower Sixth to an event to be held at the University of Cambridge later this year to reward and spur them on to apply again next year.

Comments on individual questions are given below.

Question 1: sherbet lemons

We thought that this question would be quite easy so put it first. It proved to be more difficult than we thought, however. Many candidates missed the 2:1 mole ratio of reactants in part (d). The concept of chirality was not found to be easy at this level (even though it was explained in the question) and many good scripts showed four stereoisomers in (e) by failing to spot the plane of symmetry in the meso isomer.

Question 2: redox reactions and vehicle pollution

This seemed to be an easier question and should perhaps have been put first. There were many high-scoring scripts. The most common errors were writing incorrect formulae in the equation (such as N instead of N_2), not checking that the equation balanced, and underlining the whole molecule instead of an individual atom when asked to state precisely what had been oxidised and reduced.

We had a number of enquires about the geometry of urea and so would like to elaborate a little.

Whilst ammonia has a pyramidal geometry and HNH bond angles of 107.8^{o}, amides, such as methanamide, are planar with HNH bond angles of 120^{o}. (This is of importance in the structures of proteins - giving rise to alpha helices and beta sheets.)

The structure of urea is rather interesting and a paper on its structure appeared as recently as 2005. It seems that solid urea is planar - the planar form is more polarized than the non-planar form and stabilized in the solid phase due to strong electrostatic interactions. The HNH bond angle is 120.4^{o}. However in the gas phase, and probably in aqueous solution, the nitrogen atoms assume a *slight* pyramidal form (with HNH angles 118.6^{o}). This pyramidal form has been calculated to be around 6.3 kJ mol^{-1} lower in energy than the planar form in the gas phase.

Question 3: acyl halides

As expected drawing and/or naming the shape of molecules such as $SOCl_2$ proved quite taxing; many good candidates drew it correctly but then wrote tetrahedral, confusing the geometry around the central atom with the overall shape of the molecule. Part (d) was very demanding and was perhaps the least well-answered part of the whole paper: few candidates showed clear working and so few earned any marks at all.

Question 4: copper(II) sulfate decomposition

This question was generally found to be hard. Most candidates simply didn't use the data given on the graph and 'guessed' that the molecule would decompose by loss of successive water molecules. Using graphs to extract data may be demanding at A-level, but the graph showed real experimental data so its analysis is an important skill. We originally thought of giving percentage data for the decomposition but went for a graph in the end; this has highlighted a difficulty which students often experience.

Question 5: emergency oxygen supplies

In part (b) many equations showed the formation of $BaCl_4$, presumably because students had calculated that Ba must be in oxidation state +4 to form a peroxide of formula BaO_2. The calculations in part (c) were generally done well. The equations in part (f) were often disappointing at this level, with wrong formulae such as KCO_3 appearing too often.

Question 6: Viagra ™

We were surprised and impressed with how well this question was answered. Part (a) in particular was very well done. It is nice to see such a big improvement in this sort of question compared with the answers we received to the Rimonabant question last year. There were many fewer scripts showing atoms or groups just migrating randomly around the molecule! Last year we encouraged students to keep as much of the carbon framework in the structure as intact as possible and just look for new elements appearing in the final structure; they should then put these different pieces together to see what has happened. Our advice seems to have been taken! Few candidates identified the reacting proton in (c): the reaction is seeking to connect this N to the C=O by nucleophilic attack so there is sense in the correct answer. There were also some slightly sloppy drawings in parts (d) and (e): the convention is to put in all H atoms not bonded to C in a skeletal formula, and structures for hydrazine frequently showed a double or even a triple bond between the two N atoms.

Interestingly Viagra ™ is not advertised in this country so we could not obtain a 'real' photograph of it. The comments we received from schools suggested that teachers and students particularly liked this question!

Question 7: spectra of haloalkanes

It was a pity this question came at the end of the paper since those candidates who attempted it often scored high marks; others had obviously run out of time (or steam!) by this stage. The trickiest part was (c), but other parts could generally be completed if the question was read carefully and thought about. Even the weakest candidate did well on the symmetry of F atoms in (d), but drawing three-dimensional structure was a challenge.

All committee members hope that students enjoyed the experience of attempting a really demanding paper and that teachers will use questions (and answers!) in their teaching. We hope that even more schools and even more students will be encouraged to enter the competition next year.

Tim Hersey
Chairman of the UK Chemistry Olympiad Selection Committee
2006