# GCE

# Chemistry

## CHEM5 – Energetics, Redox and Inorganic Chemistry
## Report on the Examination

2420
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Version: 1.0

**General comments**

The standard of this paper proved to be similar to that of the CHEM5 paper in June 2012. The mean mark was about one mark lower and the discrimination indicated by the standard deviation was slightly better. There was no evidence from scripts to suggest that, compared with previous years, students had been short of time to complete the paper.

**Question 1**

Most students answered part (a) well but weaker students sometimes confused lattice enthalpy with enthalpy of formation or with enthalpy of solution. Parts (b) and (c) were also answered well although in part (c), some students incorrectly suggested mass to charge ratio. Parts (d) and (e) were answered less well; the main errors in part (d) were either to use an incorrect formula of $AgCl_2$ for silver chloride or to use 60.5 instead of 121 for the enthalpy of atomisation for chlorine.

**Question 2**

This question proved to be difficult. In part (a), most students scored one mark for mentioning that the ionic radius of the chloride ion is less than that for the bromide ion. However, many weaker students lost this mark because they did not make reference to a chloride ion; often, just chlorine was mentioned. Only the best students went on to discuss how a chloride ion is attracted to the partially positive hydrogen atom in a water molecule. Others referred incorrectly to intermolecular forces or to hydrogen bonding. About 60% of students gained both marks for the calculation in part (b). In part (c)(i), most students stated that the entropy would increase but many did not clearly explain why and also that the $T\Delta S$ term would outweigh the positive enthalpy change. Although about a quarter of all students scored at least 4 marks in part (c)(ii), less than 10% went on to score full marks by subtracting the temperature change from 298 K. Marks were generally low because many students did not recognise that the heat absorbed could be calculated by multiplying the enthalpy of solution by the amount in moles of potassium chloride. Weak students also used a wrong value for the mass of water heated – usually 25 g or 5.00 g.

**Question 3**

This question proved to be easier than question 2 and was answered well by most students except for parts (a)(iv) and (b)(ii). In part (a)(iv), students were asked to explain why one line on the Figure 1 was longer than the other in terms of the behaviour of molecules. A question of this type demands an answer that compares one feature with another. Most students did not discuss the change in disorder accompanying a change in state and did not compare melting with boiling. In part (b)(ii), many students did not explain that the $T\Delta S$ term in the equation would increase as $T$ increases.

**Question 4**

This question was answered well and students of all abilities were able to score reasonable marks. In part (a), the most common error was to suggest that the conductivity of a solution could be tested. Apart from the problem that magnesium oxide is only sparingly soluble, A-level students should know that many covalent substances form ions in water so that testing the conductivity of a solution is not a good method for the identification of an ionic solid. In parts (b) and (c) only the higher-scoring students scored all marks. The marks for structure and bonding were usually gained but in part (b) a suggestion as to why water does not break down the structure was not given and in part (c) students often did not state clearly that the forces of attraction between molecules are weak.

**Question 5**

This was a testing question and in common with redox questions in previous years, performance by students was very mixed. In part (a), over 30% of students answered incorrectly that the salt bridge allowed electrons to flow through it. In part (b), students were expected to use their knowledge of copper chemistry to suggest that the chloride ions from the potassium chloride would react with the aqueous copper ions but only a very small percentage of students answered this correctly. Part (c) also proved to be a very demanding question. Only the best students gave a correct answer involving the higher concentration of copper ions in the left hand electrode. It was surprising that many students appeared to consider that the 0.2 mol $dm^{-3}$ solution of $CuSO_4$ was more concentrated than the 1.0 mol $dm^{-3}$ solution. Part (d) was very discriminating. The great majority of students answered incorrectly by stating that one of the reagents would be used up or had reacted completely. Answers to part (e) were much better. When students are asked to write an equation for an overall reaction, they should take care to cancel out identical species that appear on both sides of the final equation. In part (e)(ii), many students lost a mark because they failed to cancel out a lithium ion that appeared on both sides of the equation. In part (e)(iii), it was surprising to note that a considerable number of students thought that carbon dioxide would be produced by a reaction with an imaginary carbon electrode in the lithium cell.

**Question 6**

This question allowed all students to score marks but it also discriminated well. In part (a), the equation was almost always correct but the units of frequency were less often given correctly. In their answers to questions similar to parts (b) and (c), some students continue to suggest incorrectly that the colour observed is due to emission of light when an electron falls back down to a lower energy state. Students are penalised for this error. Over half of all students scored all three marks for part (d). Weaker students appeared to misread the question and gave general properties of transition metals, such as an incomplete d sub-shell and catalytic activity, rather than the correct properties of complex ions, such as shape and co-ordination number.

**Question 7**

Answers to this type of question demand careful attention to the colour and state of the transition metal ions or compounds before and after reaction and careful attention to balancing of equations with numbers of atoms and charges on ions. Some students continue to lose marks because they give charges on ligands within the formula for a complex ion. The only charge required on a complex ion is the overall charge that, ideally, should appear outside square brackets, although a lack of brackets was not penalised. In part (a), the most common error was to omit the observation that a gas is evolved when sodium carbonate is added to a solution containing iron(III) ions. Part (b) was answered well although some students just gave the colour of the products and did not state that solutions rather than precipitates are formed. In part (c), the most usual errors were unbalanced equations. Part (d) proved to be the hardest part of this question. Many students gave an unbalanced equation for the reaction between ammonia and aluminium ions and most students stated incorrectly that the solution of $[Ag(H_2O)_2]^+$ ions appeared to be a silver colour.

**Question 8**

This stretch and challenge question proved testing for many students, particularly parts (a) and (c). The most frequent mark for part (a) was one out of four for stating that cobalt has variable oxidation states. Attempts at the two equations were poor. Equations should be balanced and should not be half-equations with electrons. Despite the parallel with similar catalysed systems in the specification, students did not appreciate that the $Co^{3+}$ ions would be the oxidising agents, reacting with ethanal and that $Co^{2+}$ ions would be oxidised by oxygen back to $Co^{3+}$. In part (b)(i), weaker students did not know that the chelate effect is explained by entropy changes and they often, incorrectly, attempted to explain the effect in terms of the stability of a complex ion with bidentate ligands. Part (b)(ii) was answered well by most students. Part (c) proved to be very discriminating with only the very best students scoring more than three out of five marks. The most difficult marks to achieve were the formula of **Z**, $[Co(NH_3)_6]Cl_3$ and an explanation for the difference between the expected and the given ratio of cobalt ions to chloride ions in the complex. Many students lost marks because they did not use a correct formula for silver chloride – incorrectly using $AgCl_2$ or $AgNO_3$. Another common error was to ignore the precision of the data given in the question and to give the calculated molar ratio to only 1 significant figure whereas 3 significant figures were required, consistent with the data given.

**Mark Ranges and Award of Grades**

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.

**Converting Marks into UMS marks**

Convert raw marks into Uniform Mark Scale (UMS) marks by using the link below.

**UMS conversion calculator** http://www.aqa.org.uk/exams-administration/about-results/uniform-mark-scale/convert-marks-to-ums