



**General Certificate of Education (A-level)
January 2013**

Chemistry

CHEM5

(Specification 2420)

**Unit 5: Energetics, Redox and Inorganic
Chemistry**

Report on the Examination

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General Comments

The standard of this paper proved to be very similar to the Unit 5 paper in January 2011. The mean mark of 57% was similar and the discrimination indicated by the standard deviation was slightly improved when compared to the January 2012 outcomes. There was no evidence from scripts to suggest that students had been short of time to complete the paper. There were no dead marks.

Question 1

Answers to this question were disappointingly poor. In part (a), there was not much evidence that the precise meaning of the term **bond dissociation enthalpy** was understood or had been learned. Only 20% of students scored both marks and over 50% scored zero. This enthalpy change refers to the conversion of one mole of chlorine gas into two moles of chlorine atoms but this was not usually stated. Answers to part (b) did not usually convey the understanding that this process is exactly the same as bond dissociation but that it involves only half a mole of chlorine gas. There was also confusion between chlorine molecules, chlorine atoms and chloride ions. Part (c)(i) was answered better but many answers were incorrect because they did not show chlorine and fluorine molecules. In part (c)(iii), many students used incorrect cycles or formulae and obtained an exothermic rather than an endothermic answer. In part (c)(iv), most students did not read or did not understand the question. A statement that bond enthalpies are obtained by averaging values from different compounds may be a correct statement but it is not an answer to the question.

Question 2

Part (a) was usually correct. In parts (b) and (c), however, marks were often low. Too often students referred to molecules or atoms or intermolecular forces of various kinds. Even when students recognised that magnesium chloride and magnesium oxide are purely ionic, most were still unable to answer the questions. It seems that the students who answered this paper did not appreciate that they could assume a perfect ionic crystal in which the force of attraction between ions depends only on their charge and distance apart and that the distance apart is the sum of the ionic radii of the positive and the negative ions. In part (d), many students did not understand how to draw a cycle or create a formula that combined the lattice enthalpy, hydration enthalpy and enthalpy of solution using the correct + and/or – signs. Another common error was a failure to recognise that two moles of chloride ions were involved. Higher-scoring students answered part (e) well but weaker students showed a lack of understanding by suggesting that water was ionised or that the magnesium ions could hydrogen bond with water.

Question 3

Part (a) was answered well by most students. In part (b), most students scored the first 2 marks for a recognition that the entropy increases when water becomes more disordered as it changes into a gas. Only the highest-scoring students went on to explain that the free energy change is negative when the $T\Delta S$ term is greater than ΔH . Good students were able to score full marks for part (c)(i). A common error amongst weaker students was a failure to recognise that only half a mole of oxygen is involved. Part (c)(ii) also discriminated well with only the highest-scoring students giving a correct reason why water would change into hydrogen and oxygen. In part (d), good students usually scored full marks but weaker students did not get beyond a statement that $\Delta H = T\Delta S$.

Question 4

Answers to part (a) were usually correct. In part (b), weak students often confused intramolecular and intermolecular forces. In order to score both marks in a question like this, an answer must state that the stronger van der Waals' forces are between molecules. This was not often seen. In part (c), most students knew that basic oxides are usually ionic but only 18% of students could go on to explain fully how and why an oxide ion would act as a proton acceptor. Despite the statement in part (d)(i) that 'ions are formed', many students wrote an equation showing formation of the molecule H_2SO_3 . Such answers lost the mark for this part of the question and made it very difficult for a mark to be scored in part (d)(ii). Answers to part (e) were usually correct.

Question 5

This question depended on accurate recall of the reactions of metal ions in solution. It discriminated well. Good students were able to score full marks. Weaker students found the equations difficult and did not always recall correct colours. In questions of this nature, it has been reported previously but it is worthwhile repeating that an observation of a colour is only complete if the colour is tied to the species that is coloured. For instance, in part (b), a brown precipitate is formed but in part (c) the product is a deep blue solution.

Question 6

This question was answered well by most students. The most difficult part was part (d)(iii) where only the best students were able to write correct equations.

Question 7

This proved to be a difficult question. In part (a), answers were often very scrappy and disappointing. Diagrams showed a half cell that had no chance of working. The salt bridge, if present rarely dipped into a solution and the electrode material was often iron instead of the correct material, platinum. Only very good students showed a solution containing iron(II) and iron(III) ions and only the very highest-scoring students stated clearly that all aqueous species should have a concentration of 1 mol dm^{-3} . Answers to part (b) were more encouraging but only the better students realised that no platinum electrode are necessary with copper and iron electrodes. In parts (c) and (d), most students were unable to use data from the table correctly. For instance, it is correct to state that $E^\ominus \text{Au}^+/\text{Au} > E^\ominus \text{O}_2/\text{H}_2\text{O}$ but not correct to state that $E^\ominus \text{Au}^+/\text{Au} > E^\ominus \text{H}_2\text{O}/\text{O}_2$ or that gold ions are better oxidising agents than water. In this reaction, water is the reducing agent. In part (d), only 6% of students recognised that silver ions would oxidise iron to iron(II) ions and then go on to oxidise iron(II) ions to iron(III) ions.

Question 8

In part (a), the term **ligand** was usually explained correctly but only 9% of students went on to explain that a bidentate ligand donates an electron pair from each of two separate atoms in the ligand. Part (b) discriminated effectively. There was a wide range of marks with 5% of students scoring zero and about 30% of students scoring full marks. In addition to making mistakes with formulae and bond angles, weak students continue to lose marks because they attempt to indicate charges on the ligand or the metal ion of the complex. A more reliable approach is to indicate only the net charge on the complex ion, preferably outside square brackets that contain the complex. Most students scored 2 out of the 3 marks available for part (c). The missing mark was usually due to a failure to mention that the d electron energy levels are different for complexes with different ligands. Good students usually scored full marks for part (d). Marks lost by weaker students were due to use of the

wrong M_r (often the relative atomic mass of cobalt rather than the M_r for $\text{CoSO}_4 \cdot 7\text{H}_2\text{O}$) or the wrong reacting ratio for cobalt(II) and hydrogen peroxide.

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