Version 1.0

General Certificate of Education (A-level)
June 2012

Chemistry CHEM5

(Specification 2420)

Unit 5: Energetics, Redox and Inorganic Chemistry

Report on the Examination

Further copies of this Report on the Examination are available from: aqa.org.uk

Set and published by the Assessment and Qualifications Alliance.

The Assessment and Qualifications Alliance (AQA) is a company limited by guarantee registered in England and Wales (company number 3644723) and a registered charity (registered charity number 1073334).
Registered address: AQA, Devas Street, Manchester M15 6EX.

General Comments

Some students and teachers had raised concerns that this unit was harder than in previous years. In fact, this paper proved to be similar in demand to the CHEM5 paper in June 2011. The mean mark was about one mark lower and the discrimination, indicated by the standard deviation, was slightly better. There was no evidence from the scripts or from marking statistics to suggest that, compared with previous years, students had been short of time to complete the paper.

Question 1

Most students answered part (a) correctly by stating that phosphorus would be kept out of contact with air/oxygen or that phosphorus reacts with oxygen. In part (b), it was expected that students would understand that P_4O_{10} represents a single molecule with 4 atoms of phosphorus and ten of oxygen but this answer was seldom seen. A very common wrong answer was to suggest that the representation P_4O_{10} is used because it is more stable than P_2O_5. Answers to part (c) were often good but common mistakes were to refer to SO_2 rather than SO_3 and to state that P_4O_{10} is macromolecular. A common omission was a failure to explain that van der Waals' forces are between molecules. Part (d) was answered well by most students. Part (e)(i) was answered correctly by good students but weaker students sometimes could not give a correct formula for a magnesium phosphate and sometimes used phosphorus(V) oxide instead of phosphoric(V) acid. In parts (e)(ii) and (iii), some students did not appreciate that the question referred to an excess of the reagent and confined their answers to the neutralisation reaction only. Many students did not appreciate or mention that magnesium oxide is sparingly soluble.

Question 2

It is pleasing to report that a majority of students scored very well in this question. Some students did lose a mark for a lack of precision in their calculation of the slope giving an answer of 0.1 instead of the expected 0.098.

Question 3

In part (a), it was disappointing to find that students continue to be unable to give precise definitions of thermodynamic terms. Many students failed to score full marks for recalling the meaning of the term electron affinity. Common errors were to mention energy instead of enthalpy change, a failure to mention one mole and omitting to state that the atoms and then the ions formed must be in the gaseous state. In part (b), mention of molecules or ions rather than atoms spoiled some answers and only the best students mentioned attraction of a bonding pair of electrons to the fluorine nucleus. Answers to part (c) were often disappointing with only about 22% of students scoring both marks. Students at this level should appreciate that electronegativity is a property of atoms in molecules and has no place in an explanation of the hydration enthalpy of an ion. Students also lost marks for referring to fluorine rather than to the fluoride ion. The most common error in part (d)(i) was to use the wrong sign for the enthalpy of solution. Students may have been more likely to obtain a correct answer if they had drawn out a cycle but few did. Another fairly common error was to use the incorrect formula of AgF_2 for silver fluoride. It is pleasing to report that parts (d)(ii) and (iii) were answered well by most students.

Question 4

This question, except for part (d), was answered well by many students of all abilities. In part (d), only the best students appreciated that the reaction would not be feasible above 794 K and, therefore, predicted that this temperature is exceeded in internal combustion engines.

Question 5

Part (a) was answered well. The most common error was to give the meaning of oxidation rather than an oxidising agent. Answers to part (b) were very often incorrect. All of the species from the table were seen in students' answers. The most common wrong answer was probably 'cadmium'. It still seems to be the case that many students do not understand that when redox half–equations are presented in their standard form with electrons on the left, the species on the left are oxidising agents and the species on the right are reducing agents. Parts (c)(i) and (ii) were answered correctly by most students. Part (c)(iii) proved to be more testing and only the best students recognised that the porous partition was acting in the same way as a salt bridge by permitting the transport of ions. Parts (c)(iv) and (v) were answered quite well although in part (c)(v) it was not always realised that the zinc container reacts to form zinc ions whilst the cell is in operation.

Part (d)(i) proved to be a discriminating question. An oxidation state of +2 for nickel in NiO(OH) was a common error and the equation was often unbalanced or not simplified by removing hydroxide ions. Part (d)(ii) was almost always answered correctly. In comparison, parts (e)(i) and (ii) were not answered well, usually because of a lack of attention to detail. Instead of using ethanol, a common mistake was to use CH_3OH. In part (e)(i), the equation for the combustion of ethanol was often unbalanced because students seemed to fail to take into account the oxygen in the ethanol. In part (e)(ii), despite being asked to write a half-equation, the electrons were often omitted or the numbers of hydrogen ions and electrons were wrong. Answers to part (e)(iii) were usually correct. In part (e)(iv), it seems that many students are still not clear about the meaning of the term carbon-neutral. The term is too often thought to refer just to carbon rather than to carbon dioxide in the atmosphere. Also, the majority of students did not make it clear that the carbon dioxide, released into the atmosphere by the processes that manufacture and use ethanol, can be balanced by the carbon dioxide taken out of the atmosphere by photosynthesis in plants.

Question 6

This question was answered well by most students. In part (b), a mark was lost by those students who failed to mention that the electron pair donated to the iron(II) ion by water was donated by oxygen. Part (d)(i) was the most demanding part of the question but it was pleasing to find that 37% of students gave the correct reacting ratio of 3:5 for MnO_4^-:FeC_2O_4. Many students tried unsuccessfully to write a balanced equation. The best students did not attempt an equation. They realised that the reduction of manganate(VII) ions is a 5-electron change reaction. The oxidation of FeC_2O_4 is a 3-electron change reaction. Therefore, the reacting ratio is 3:5. Answers to part (d)(ii) were awarded method marks and most students scored at least 4 out of the 5 marks available. Some students lost a mark for an incorrect relative formula mass of $FeC_2O_4.2H_2O$ and some for an incorrect method of calculating the percentage. Some students who used their own incorrect ratio obtained in part (d)(i) and those who used the alternative 3:7 ratio given in the question obtained an apparent mass of iron(II) ethanedioate that was greater than the original mass. A common error was for students to calculate a percentage with the mass of the impure compound as the numerator rather than the denominator.

Although question 6(d)(ii) could still be answered and all students were able to access all of the available marks, we recognise that the alternative ratio given was unhelpful and caused confusion for some students. We apologise for this and accept that it would have been better to have provided a different ratio. During marking of this question, senior examiners identified any student who used the 3:7 ratio. These students' scripts were then reviewed by experienced senior examiners and special consideration was given to any student who had clearly been disadvantaged by using the given ratio.

Question 7

In part (a), the equations were usually correct but the colours of the ions were not always correct and not always identified to an ion. Occasionally the reduction was not continued as far as chromium(III) and sometimes the reduction was continued, incorrectly, from chromium(II) to chromium metal. This was not penalised. Answers to part (b) were generally correct though marks were lost due to careless mistakes where equations were not balanced with the correct number of hydroxide ions or the correct number of waters displaced. A significant number of students continued to lose marks by showing a correct overall charge for a complex with hydroxide ligands but also showing, incorrectly, a negative charge on the hydroxide ligand.

The type of reaction in part (c) was usually correct but many students did not give a correct answer to the remainder of the question. Students were asked to suggest why the colours of the complex ions are different. Many chose to ignore the request to explain the difference in colour and simply explained why a complex appears coloured. Only the very best students suggested that the energy gap between the d-electron energy levels must be different in complexes with different ligands. A surprising number of students stated incorrectly that the oxidation state of chromium in $[Cr(H_2O)_6]^{3+}$ was different from that in $[Cr(H_2O)_5Cl]^{2+}$ and, therefore, the two complexes had different numbers of d electrons. In part (d), students generally deduced that the chromium(II) ion would be oxidised to chromium(III) by oxygen but they did not use the electrode potential data correctly to explain why. It was a very common error to use the data to suggest that oxygen is a better oxidising agent than chromium(II). In this reaction chromium(II) is the reducing agent. The last one or two marks of part (d) were often missed. A correct explanation for the increased acidity of aqueous chromium(III) ions compared with aqueous chromium(II) ions was only given by the best students.

Question 8

Answers to part (a), a question that required recall of cobalt chemistry, produced a wide spread of marks. As always, a full identification of reagents was required and many students lost marks by failing to do so, specifying Cl^- (instead of HCl), carbonate (instead of sodium carbonate) and hydroxide (instead of NaOH). Missing or incorrect charges and inaccurate formulae were also common eg $CoCl_4$ and $Co(OH_2)$. Reaction 1 was well known. Air was a common insufficient reagent for reaction 2. The equation mark for reaction 2 was often the missing mark from an otherwise perfect answer. Reaction 3 was the least well known of the four reactions. Many students did not recognise the blue solution to be $[CoCl_4]^{2-}$ and instead attempted to use an excess of NaOH to give a cobaltate(II) ion. In reaction 4, $NaCO_3$ and CO_3^- were common wrong answers. In part (b), most students gained the first two marks. Although most students attempted the last two equations, very few were correct. Common wrong answers involved the wrong cobalt species being used. For example, students tried to oxidise sulfate(IV) ions with cobalt(II). They did not recognise that an oxidising agent must react with a reducing agent and they went on with an attempt to reduce cobalt(III) to cobalt(II) with oxygen.

UMS conversion calculator www.aqa.org.uk/umsconversion

Results statistics http://web.aqa.org.uk/over/stat.php?id=01&prev=01