Examiners' Report/ Principal Examiner Feedback

January 2014

IAL Chemistry WCH02/01
Unit 2: Application of Core Principles of Chemistry

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Introduction

The paper had questions which addressed the whole-ability range and so was accessible to all candidates. There was no evidence of any shortage of time. There are a few calculation questions on the paper which were generally done well by all but also enabled distinctions to be made between candidates of differing ability. Many candidates showed limited knowledge of practical techniques and the responses to questions which were created around the theme of 'How Science Works' were disappointing and these proved to be very discriminating. The most demanding questions were those which required the application of chemical concept and principles.

Question 21

The use of oxidation numbers in part (a)(i) to confirm that the reaction was not redox was generally done by all but some candidates gave an oxidation number change after stating that the reaction was not redox. Only the more able candidates appreciated that part (a)(ii) was a question related to the equilibrium of the reaction and hence served as an effective discriminator. A novel and challenging 'dot and cross' diagram was the subject of (a)(iv) and only the very able correctly completed the diagram. A common error was misreading the rubric concerning Iodine in the molecule having 12 electrons in its outer shell. This is illustrated in the example below where the candidate has given the iodine 12 electrons and then attempted, incorrectly, to show the bonding.

Insert image of Q21(a)(iv) from doc id QC0352600018653

This element has a total of 12 electrons in its outer shell as a result of the bonding and does not use 12 of its electrons to engage in bonding. However the middle-ability candidates were able to gain the mark for the electrons around each of the oxygen atoms at the four corners and so this question gave a good spread of marks. Part (a)(v) was one example of the type of question on the paper where application of principles was required and a wide range of possibilities was seen and so also provided a means of discriminating between ability.

The calculation in part (a) (i) – (vii) were usually well done. Candidates have been well-taught concerning the need to use more than one significant figures and to use correct units. The exception was part (iii) were answers to one significant figure were allowed. Part (vii) proved to be the most effective discriminator between differing abilities, often it was left blank by those of lower ability while at the top end the candidates could efficiently use their molar ratio from the equation in part (vi). The question of part (a)(viii) was similar to one on the paper in June 2013 and the level of responses demonstrated that many candidates had learnt that it is not possible to simply repeat a titration when all of the sample had been used. Hence the more discerning candidates either suggested splitting the sample or simply repeating the whole experiment.

In part (c)(i) a significant number of candidates did not read the question carefully and failed to address the point of reducing the production of the pollutant, carbon monoxide. Other candidates simply suggested using alternative fuels but this would not resolve the problem. Only the more able correctly stated use of a catalytic converter for this purpose. In (ii) it was disappointing to see so few candidates correctly explain the meaning of the term 'carbon-neutral' when this is a major global issue. A significant proportion of candidates only referred to **carbon** instead of carbon dioxide in their explanation as illustrated in the example below.

(ii) Explain the meaning of the term 'carbon-neutral' and give an example of a motor vehicle fuel that can be classified in this way.

(2)

Carbon neutral refers to the amount of carbon used and produced in any process being equal.

* Bio-fuel

(Total for Question 21 = 19 marks)

A significant number of candidates thought that petrol or diesel is such a biofuel which was also worrying. The general term 'biofuel' was allowed although an example of such was actually required by the question.

Question 22

The thermit reaction is an excellent demonstration for illustrating the application of chemistry to the real world and of key chemical concepts. This and other such demonstrations certainly would be very beneficial for all chemistry candidates to have either seen their teachers demonstrate or to have viewed electronically so that the candidates can be inspired to see how important chemistry is to everyday life. However the questions asked here could have been correctly answered by candidates who hadn't seen the thermit demonstration themselves.

The equation needed in (a) was correctly completed for the vast majority of candidates, although the occasional Fe_2, Fe^{2+} and Fe^{3+} were seen. The mass of Al_2O_3 required in (b) proved to be a high-scoring question with many scoring all available marks

Part (c) proved very challenging and therefore low scoring with many answers reflecting a lack of awareness of what actually a sensible suggestion. The main example of this was the answer 'calcium chloride'. Indeed this is a drying agent which is presumably what the candidates focussed on but it is used to dry liquids and this question was requiring a way to dry solid iron(III) oxide. The addition of a solid to a solid in order to dry it really does not make sense and if candidates had thought about their answer from a practical point of view then they would have realised that it was incorrect. A desiccator was another suggestion but this apparatus keeps substances dry but does not actually dry them. An oven is required but alas was rarely seen.

The application of collision theory was required for part (d) but candidates struggled to clearly express themselves, for example, "because they are both solids" and "to increase the rate of reaction" were both insufficient to score.

The multiple parts of (e) were used as a means for testing standard chemical topics through the thermit reaction and for some question parts the responses seen were very poor. The first two parts (i) and (ii) were straight-forward and high-scoring, however the weaker candidates simply put 'bright light' for (i) which was insufficient since the light is very clearly 'white'.

The Maxwell-Boltzmann diagram proved to be an effective discriminator and gave the whole spread of marks. There were some common errors which candidates could be reminded to avoid. The x axis is not 'time' and the y axis is neither 'energy level' nor 'enthalpy change'. In addition, the careless error of transcription of 'kJ mol^{-1}, as 'kJ', was seen as in the example below.

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In the rubric, the value of the enthalpy change was given and frequently this was not used and occasionally an endothermic diagram was drawn. A lack of understanding of the role of the magnesium fuse was also evident here with magnesium given as the reactant and magnesium oxide given as the product, again as illustrated below.

Insert image of Q21(a)(iv) from doc id QC0352600019057 (The doc ID does not match the question, please check the doc ID again)

Only the weaker candidates failed to score the mark for (iv), although some simply re-wrote the wording of the question by stating that "the magnesium fuse initiates the reaction". Likewise in part (v) the weaker candidates tended to just give the standard definition of a catalyst or to state that the magnesium fuse does not speed up the reaction. However the fuse does speed up the reaction. The key point required was that the magnesium is changed at the end of the reaction. Some candidates stated that magnesium was not a catalyst because it took part in the reaction but all catalysts take part in some way or other in the reaction since the reaction rate is increased and so this was not credited.

Part (vi) was very low-scoring. Candidates did not appreciate that the thermit reaction is self-sustaining and so once started it provides its own energy. Likewise part (f) was poorly answered with the stock answer referring to an explosion. In order for credit to be given there needed to be reference to a suddenness of a reaction occurring or of a delay.

In part (g) the thermit reaction was viewed as simply a source of heat which would melt the railway lines and hence allow them to be joined. The product of molten iron was completely ignored or forgotten which was very disappointing seeing as the thermit reaction is a commonly used technique in many countries for repairing railway lines.

The final part (h) was very high-scoring with the vast majority of candidates appreciating that aluminium is readily available and cheaper than other reactive metals that could be used.

Question 23

It was very surprising to see so many candidates struggle with the requirement of the molecular formula required in part (a). It had been anticipated that the skeletal formula would present the challenge but a large proportion of candidates did not seem to understand the meaning of the term 'molecular formula' because names were frequently quoted. Similarly in (b) the question required a name and not simply copying out the bond shown above on the paper. This seemed to be more evident with the weaker candidates.

The reaction equations and observations in part (c) proved to be effective discriminators. It was pleasing to see many correct equations for the phosphorus(V) chloride reaction. The sodium in the alkoxide was shown as being between the R group and the oxygen as shown in the example below. This is incorrect and was penalised.

Insert image of Q23(ca) from doc id QC0352600018744

Na^+O^- $+\frac{1}{2}H_2$

(c) The presence of an OH group can be detected by the use of sodium or by the use of phosphorus(V) chloride, PCl_5.

Using the formula R-OH, complete the balanced equations for both of these reactions and give one observation for each of them. State symbols are not required.

(i) The reaction with sodium

(2)

Equation ROH + Na $\rightarrow$ $RNaO^-$ $+\frac{1}{2}H_2$

Observation Sodium disappears

(ii) The reaction with phosphorus(V) chloride

(2)

Equation ROH + PCl_5 $\rightarrow$ RCl + $POCl_3$ + HCl

Observation White misty fumes

(iii) In each reaction a hazardous gas is produced. By considering the hazards associated with each of these gases, suggest which poses the greater risk. Justify your answer.

(2)

In reaction with sodium, sodium ethoxide is produced while in reaction with PCl_5, hydrogen chloride gas is produced. HCl poses a greater risk as it has the ability to form chlorine free radicals which cause ozone layer depletion.

The example above also illustrates an erroneous view that the HCl, or chlorine, produced from the reaction in (ii) would be detrimental to the ozone layer. This negated any correct comment relating to the corrosive nature of hydrogen chloride.

The likely lack of practical experience became evident in the answers to part (iii) because a significant minority expressed the view that the hydrogen released from the reaction of sodium with alcohol would be the most hazardous due to the possibility of an explosion. Whilst it is true that hydrogen gas is flammable, the volume of gas and the rate of production with an alcohol is so small that this risk is negligible. Only those candidates who have either carried this reaction out or who have seen it demonstrated appreciated this fact.

The questions in part (d) resulted in the full range of marks and proved to be helpful discriminators. Sulfuric acid and sodium/potassium dichromate were the acceptable reagents for (i). It was not uncommon for potassium manganate(VII) to be given as the oxidizing agent either with or without the dichromate. This reagent is an oxidizing agent but too powerful for the requirement of producing an aldehyde from an alcohol. Hence this resulted in a loss of mark for those candidates, although the mark for the acid was awarded if it was named correctly. Only the more able candidates appreciated that the condition required for this conversion was 'distillation'. In (ii) there was considerable confusion seen, especially with the lower-ability candidates. For example, despite the question clearly referring to infrared spectroscopy there were significant numbers of candidates discussing mass spectrometry. In the June R paper the effect of infrared radiation on bonds was requested and it was similar here, but it would appear that some candidates remain under the impression that the whole molecule vibrates rather than the bond itself. Strictly-speaking the bond vibrates <u>more</u> and it would be good for candidates to be reminded of this.

Part (e) was a most effective discriminator because it allowed the whole ability range to gain credit of different amounts. The lower-ability candidates tended to only gain the marks for the identification of the respective intermolecular forces. However the more-able candidates demonstrated a clear understanding of how these forces arise but care needed to be taken to highlight the point that the hydrogen bonding described for alcohols was indeed intermolecular. In the example below this is not clearly expressed and so that particular mark was not awarded.

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Parts (f) and (g) were only correctly answered by the higher-ability candidates. In (f) the reference to the molecular or parent ion peak was frequently given as the means to distinguish different chemicals but of course a number of substances have the same relative molecular mass, such as ethanoic acid and propan-1-ol or propan-2-ol. It is the unique fragmentation pattern that differentiates substances. The answers seen to (g) were often too vague as it needed to be clearly expressed that the chemicals causing the aroma were not affected by the enzymes concerned. It was possible to acceptably express this in a number of different ways.

Summary

There were a number of questions where it was obvious that the candidates had not read the question carefully. It is always advisable for candidates to make sure that they have time to re-read their answers and to double-check that they have answered the question set.

Chemistry is a practical subject and there will always be many questions that have a practical aspect. Hence it is vital that candidates get the opportunity to either carry out practical work themselves or to see it carried out. This will be immensely beneficial as they will have a much richer experience and learn much more than simply reading on the topic from a textbook.

In addition the application of chemical concepts to 'real-life' situations or to common chemical demonstrations is a very good way to illustrate the importance of chemistry and to highlight its relevance to young people today. Hence this should always be a reoccurring theme in the delivery of the specification.

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