Examiners' Report
June 2015

IAL Chemistry WCH05 01

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Intoduction

This examination was typical of recent examinations in this series, with a mix of standard and higher demand questions. Examiners were pleased to see some excellent work from well prepared candidates, particularly on the more straightforward questions. Most questions were answered very well by a good number of candidates, but some were challenging to all but a few. Questions with a significant synoptic element, or requiring knowledge and understanding of practical techniques scored lower marks, with only 12% of candidates able to fully describe the production of a standard solution. Only 2% of candidates were able to identify the formation of MnO_2 in a manganate(VII) titration with too little acid, and explain how this would affect the titration value. Generally candidates proved proficient in the more common calculations. Unusual calculations, such as 24(c)(ii) posed more of a challenge.

Multiple Choice

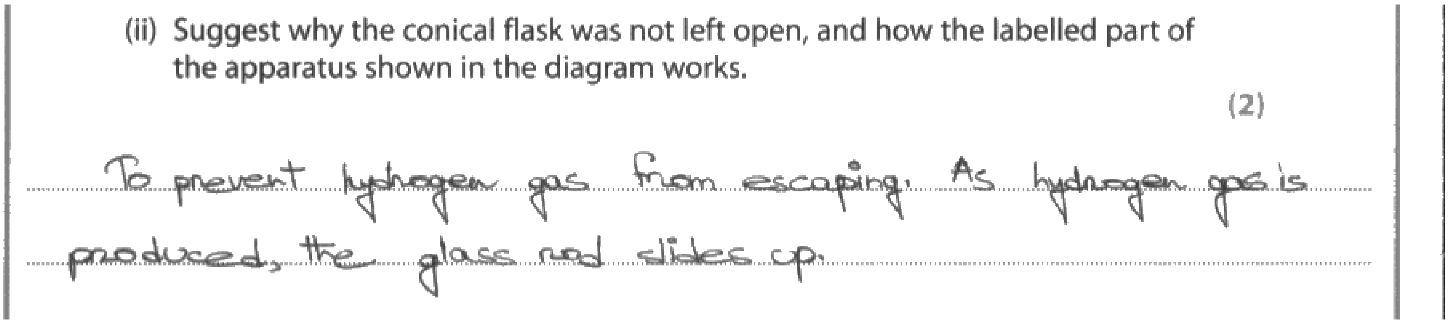
This discriminated quite well across the cohort, with candidates finding this section rather more difficult than in recent papers. The hardest questions, questions 10 and 8, were answered correctly by only 21% and 25% of candidates respectively. The easiest question, question 12, was answered correctly by 90%. The majority of questions were correctly answered by between 45% and 70% of candidates. On average, A grade candidates scored around 70%, whilst candidates achieving an E grade scored just over 50%.

Question 21 (a) (i)

The equation was well understood, with many candidates scoring the mark. Errors included the production of water or reactions where H^+ was present as a product. Few candidates omitted the state symbols, which were usually correct when present.

Question 21 (a) (ii)

Many candidates recognised that oxygen in the air might cause oxidation of the Fe^{2+} ion, but a significant number thought it was the iron metal that would be oxidised. Very few recognised how the split rubber tube and glass rod would work to allow the release of pressure caused by a build up of hydrogen by allowing the hydrogen out but not letting air in.



(ii) Suggest why the conical flask was not left open, and how the labelled part of the apparatus shown in the diagram works.

(2)

To prevent hydrogen gas from escaping. As hydrogen gas is produced, the glass rod slides up.

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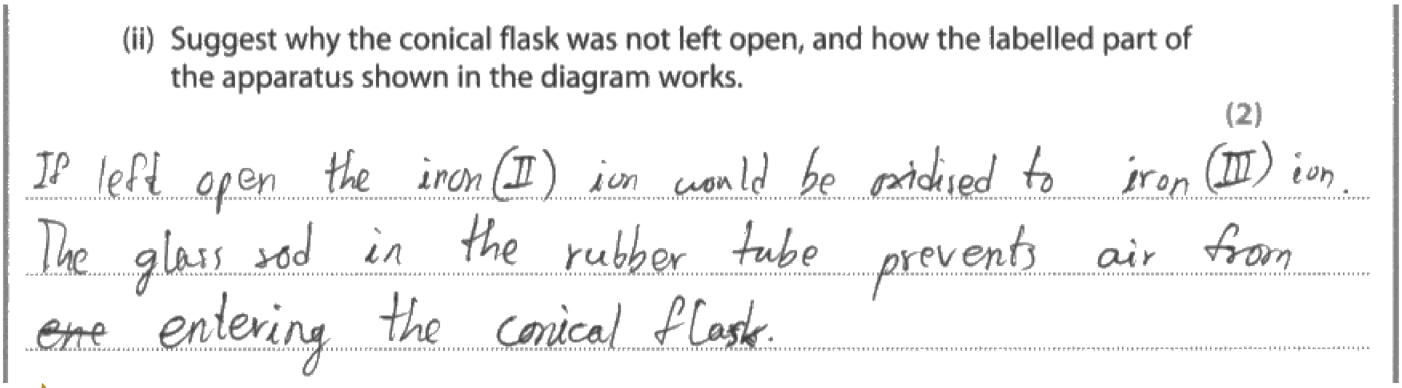
Examiner Comments

Typical of an example where the candidate did not recognise how the Bunsen valve would work, this did not score the first mark.



(ii) Suggest why the conical flask was not left open, and how the labelled part of the apparatus shown in the diagram works.

(2)

If left open the iron(II) ion would be oxidised to iron (III) ion. The glass sod in the rubber tube prevents air from ~~ene~~ entering the conical flask.

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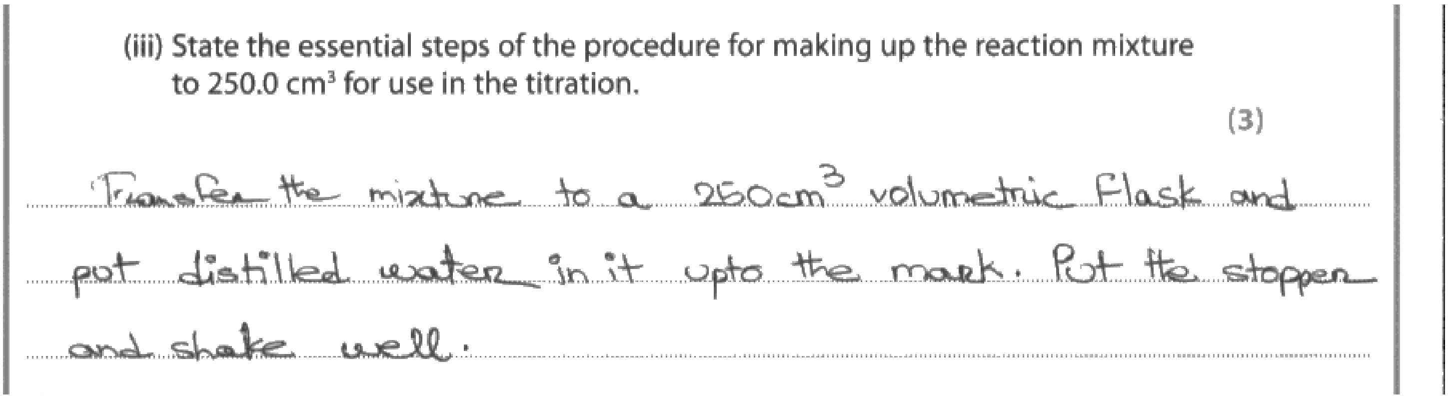
Examiner Comments

Another example where excluding air was recognised as being important, but not the prevention of the build up of pressure. This example scored one mark.

Question 21 (a) (iii)

This question required candidates to recall how to make up a standard solution, and adapt their knowledge to the context of the question. Many were able to score some marks, usually by employing a volumetric flask in which to measure the volume of the solution.



(iii) State the essential steps of the procedure for making up the reaction mixture to 250.0 cm³ for use in the titration.

(3)

Transfer the mixture to a 250cm^3 volumetric Flask and put distilled water in it upto the mark. Put the stopper and shake well.

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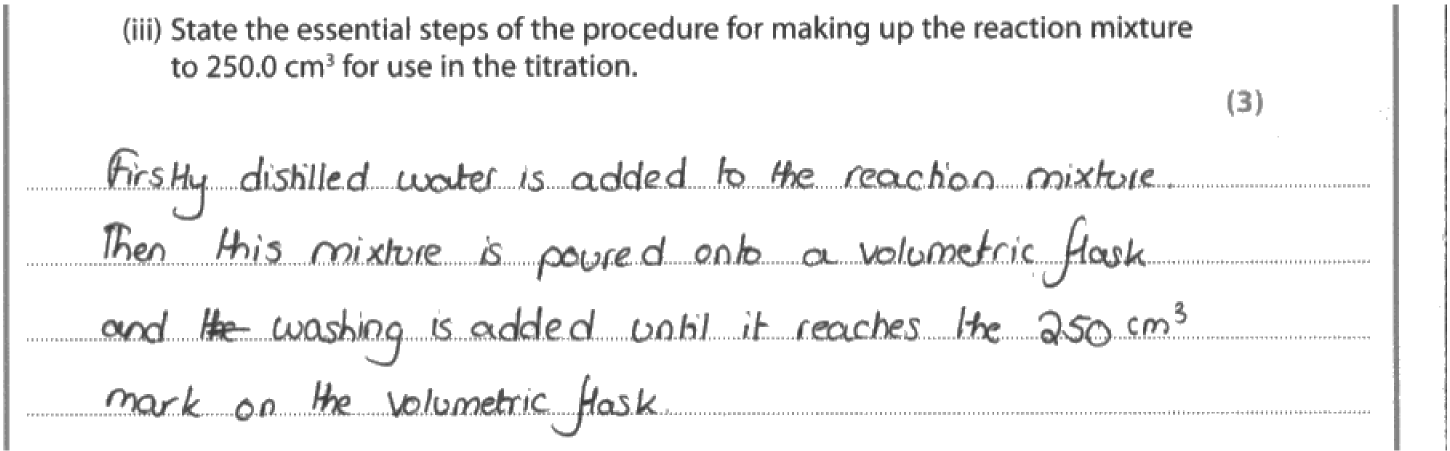
Examiner Comments

This was a typical response, scoring two out of three marks. The use of the volumetric flask scores the first mark, then making up to the mark with shaking after to ensure mixing scoring the third of the available marks.



(iii) State the essential steps of the procedure for making up the reaction mixture to 250.0 cm³ for use in the titration.

(3)

Firstly distilled water is added to the reaction mixture. Then this mixture is poured onto a volumetric flask and the washing is added until it reaches the 250 cm^3 mark on the volumetric flask.

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Examiner Comments

Here again two marks were scored. This time the flask is not shaken after making up to 250cm^3, so the third marking point was not awarded. The candidate has remembered to rinse the conical flask to ensure all the solution is in the volumetric flask so scores the second marking point.

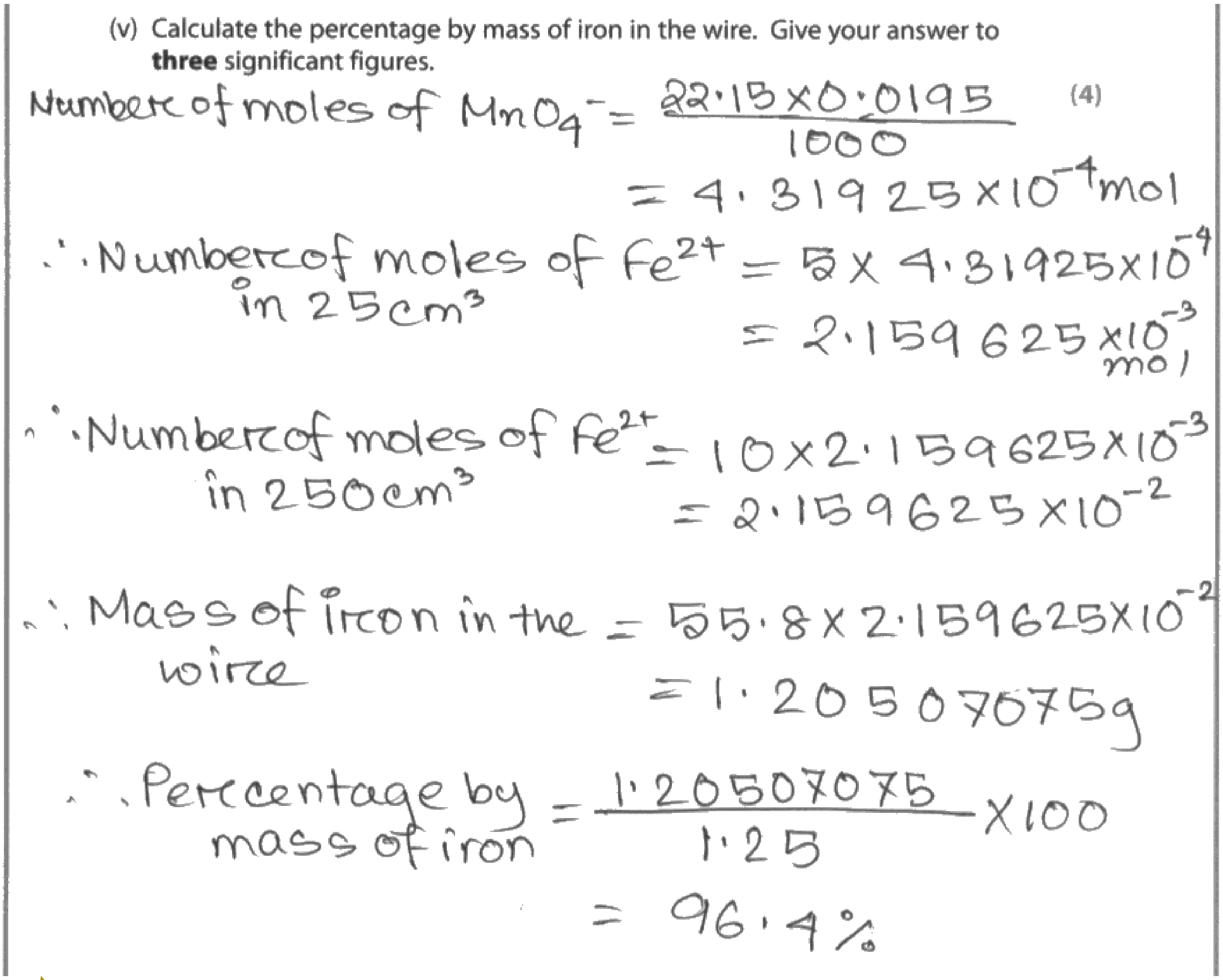
Question 21 (a) (iv)

The equation in this item was very well known, or very well worked out, by a large number of candidates. Errors included missing out the water on the product side, or using MnO_4^{2-} as the formula for manganate(VII).

Remember that it is a good idea to know the formulae of some of the more common ions which are encountered at this level, for example the manganate(VII), dichromate(VI) and thiosulfate ions.

Question 21 (a) (v)

There were many excellent responses to this calculation question, which was very well answered by many candidates, with four marks being scored by 57% of candidates.



(v) Calculate the percentage by mass of iron in the wire. Give your answer to **three** significant figures. (4)

Number of moles of $MnO_4^- = \frac{22\cdot15 \times 0\cdot0195}{1000}$

$= 4\cdot31925 \times 10^{-4}$ mol

$\therefore$ Number of moles of Fe^{2+} in $25 cm^3$ $= 5 \times 4\cdot31925 \times 10^{-4}$

$= 2\cdot159625 \times 10^{-3}$ mol

$\therefore$ Number of moles of Fe^{2+} in $250 cm^3$ $= 10 \times 2\cdot159625 \times 10^{-3}$

$= 2\cdot159625 \times 10^{-2}$

$\therefore$ Mass of iron in the wire $= 55\cdot8 \times 2\cdot159625 \times 10^{-2}$

$= 1\cdot20507075 g$

$\therefore$ Percentage by mass of iron $= \frac{1\cdot20507075}{1\cdot25} \times 100$

$= 96\cdot4\%$

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Examiner Comments

This is a particularly neatly laid out example so that identifying where the candidate scored the four marks was easy.

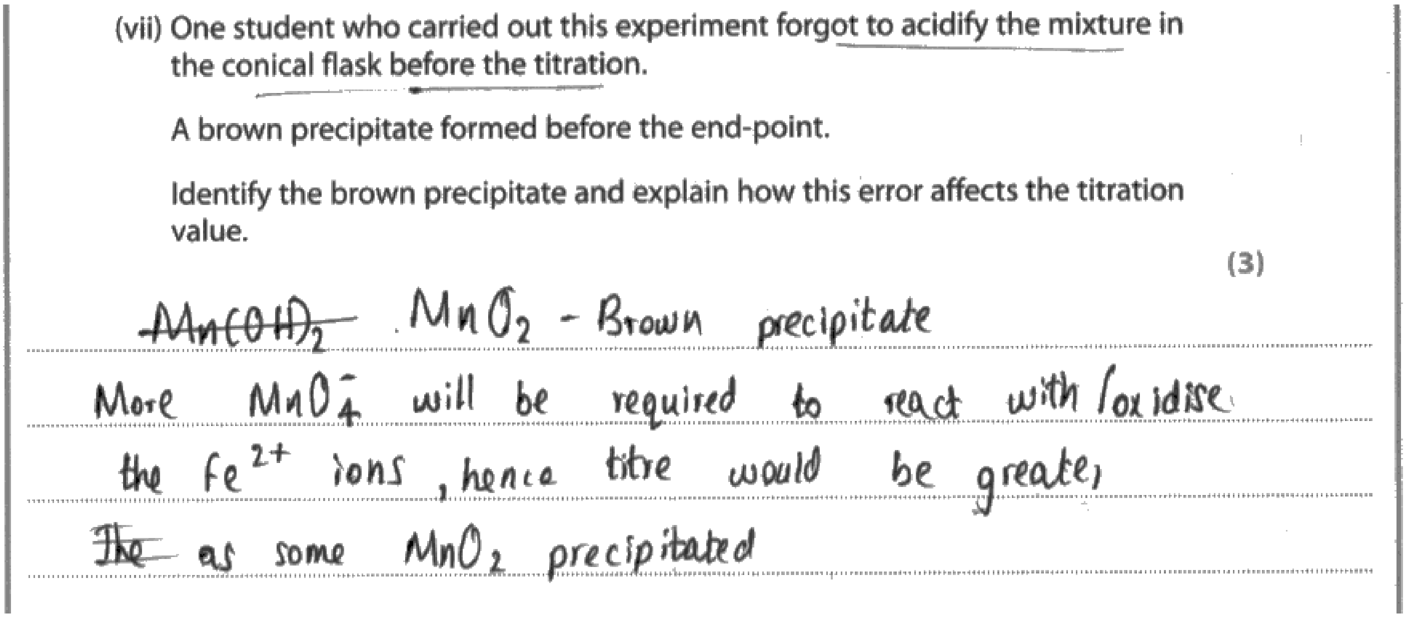
Question 21 (a) (vi)

This question was extremely well answered by many candidates, although the use of purple as the final colour of the solution was quite a common error.

It is a good idea to learn the correct colour changes for the end-points of standard titrations.

Question 21 (a) (vii)

Many answers to this question started with the idea that the precipitate was either an iron(II) or iron(III) compound, commonly ‘rust’. This made any further marks very difficult. It was unusual to see fully correct answers even when MnO_2 was selected as the compound responsible for the precipitate, as attempts to justify the need for a higher titration volume were rarely attempted.



(vii) One student who carried out this experiment forgot to acidify the mixture in the conical flask before the titration.

A brown precipitate formed before the end-point.

Identify the brown precipitate and explain how this error affects the titration value.

(3)

~~$Mn(OH)_2$~~ MnO_2 - Brown precipitate

More MnO_4^- will be required to react with /oxidise the Fe^{2+} ions, hence titre would be greater, ~~The~~ as some MnO_2 precipitated

ResultsPlus

Examiner Comments

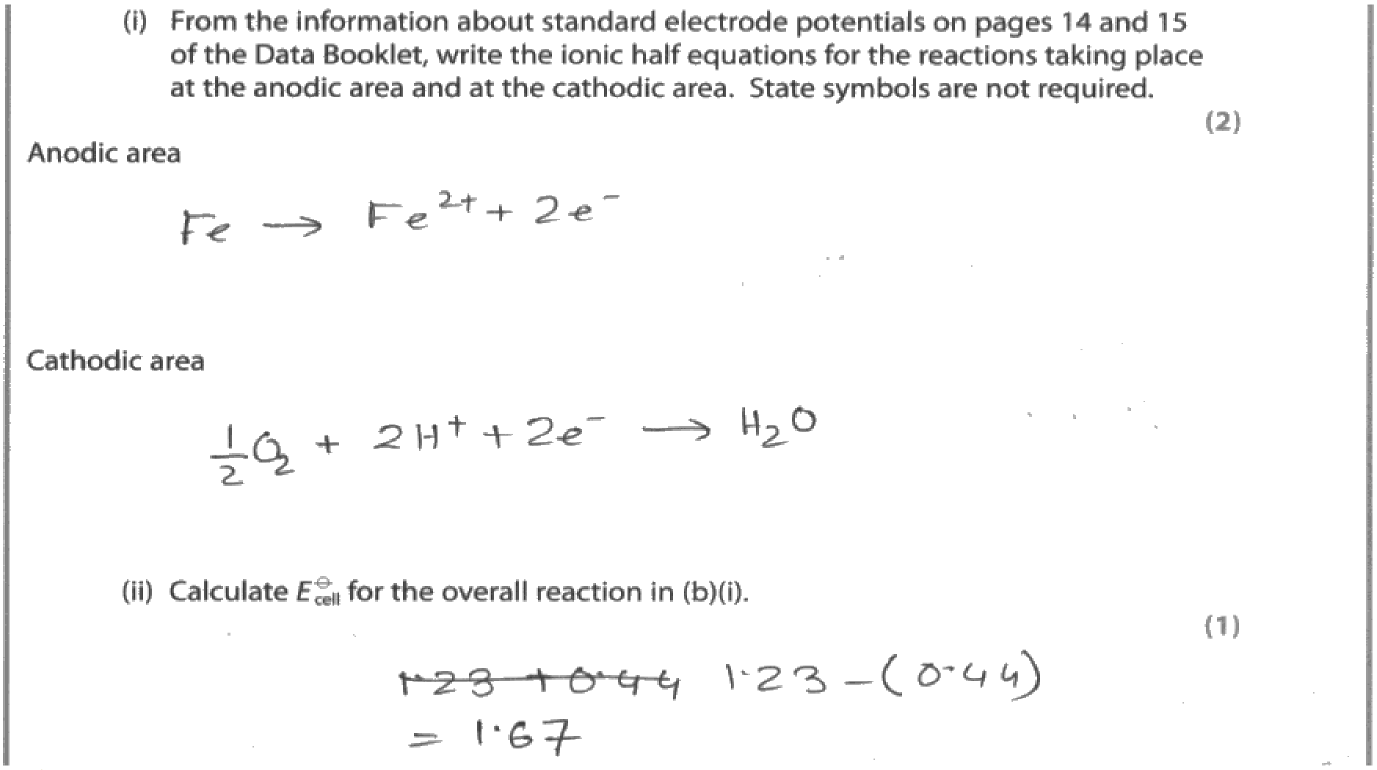
This was a typical example which scored 2.

Question 21 (b) (iii)

There were a number of ways to answer this question, but very few candidates were able to express themselves with sufficient clarity to be awarded the mark. It was not clear from their answers what was carrying charge and where it was being carried. It was also quite common to see attempts to answer in terms of the salt being a catalyst.

Question 21 (b) (i-ii)

This set of questions differentiated well across the ability range. Many fully correct answers were given using the first alternative answer for the cathode reaction along with a correct equation for the anode. Candidates almost always added electrons to the simple equation involving iron converting to iron(II), but a large number omitted the electrons in the equation for the cathodic area.



(i) From the information about standard electrode potentials on pages 14 and 15 of the Data Booklet, write the ionic half equations for the reactions taking place at the anodic area and at the cathodic area. State symbols are not required.

(2)

Anodic area

$Fe \rightarrow Fe^{2+} + 2e^-$

Cathodic area

$\frac{1}{2}O_2 + 2H^+ + 2e^- \rightarrow H_2O$

(ii) Calculate $E^{\ominus}_{cell}$ for the overall reaction in (b)(i).

(1)

~~1·23 + 0·44~~ 1·23 − (0·44)

= 1·67

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Examiner Comments

This example scores all three available marks using the quite commonly used ALLOW equation from the mark scheme for the cathodic area and the resulting calculated value of +1.67 V.

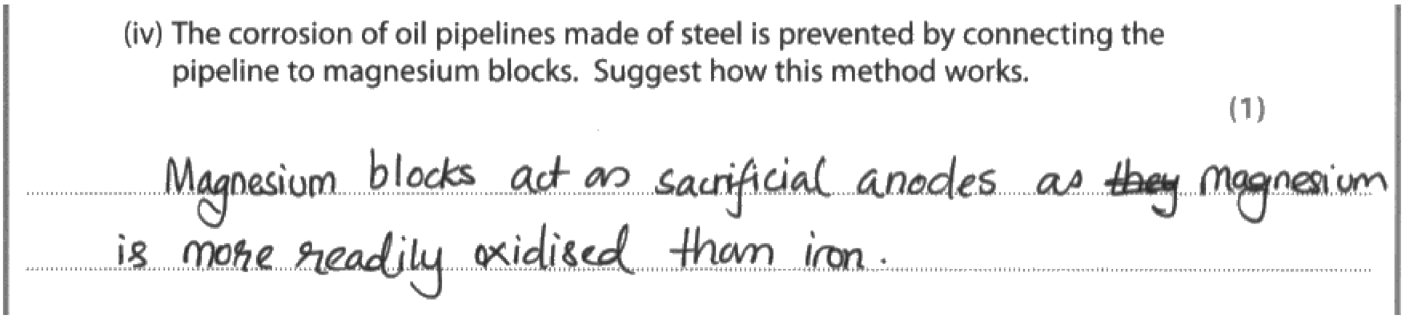
ResultsPlus

Examiner Tip

Check your redox half equations are balanced for charge by adding up the charge on both sides of the arrow, and adding electrons to make them equal if necessary. Remember that the cell notation used on pages 14-16 of the data booklet omit the electrons that are required for the ionic half equations.

Question 21 (b) (iv)

Candidates found this quite difficult to answer, with most who scored the mark using the idea of preferential oxidation. Many candidates believed that the magnesium would form an unreactive protective layer around the pipe.



(iv) The corrosion of oil pipelines made of steel is prevented by connecting the pipeline to magnesium blocks. Suggest how this method works.

(1)

Magnesium blocks act as sacrificial anodes as ~~they~~ magnesium is more readily oxidised than iron.

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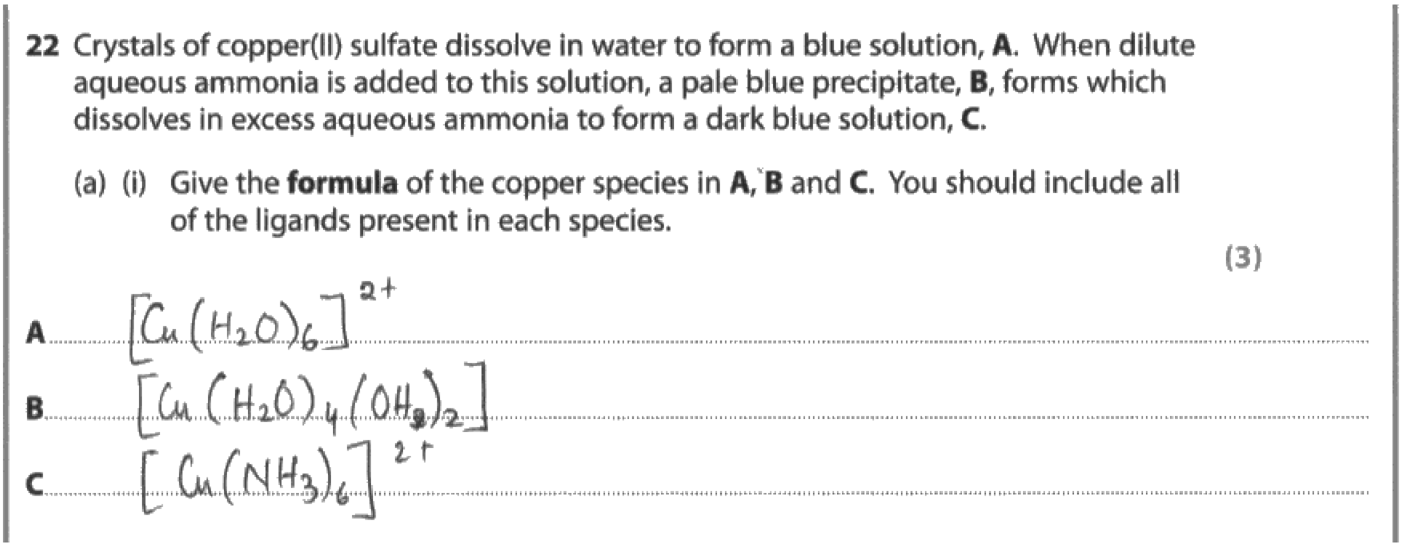
Examiner Comments

A good example using both of the ALLOW statements in the mark scheme.

Question 22 (a) (i)

This question proved surprisingly difficult, with candidates finding a number of ways *not* to score the marks, including incorrect charges on the complex ions and an incorrect number of ligands. The examples show some correct and some typically incorrect responses.



22 Crystals of copper(II) sulfate dissolve in water to form a blue solution, **A**. When dilute aqueous ammonia is added to this solution, a pale blue precipitate, **B**, forms which dissolves in excess aqueous ammonia to form a dark blue solution, **C**.

(a) (i) Give the **formula** of the copper species in **A**, **B** and **C**. You should include all of the ligands present in each species.

(3)

A $[Cu(H_2O)_6]^{2+}$

B $[Cu(H_2O)_4(OH)_2]$

C $[Cu(NH_3)_6]^{2+}$

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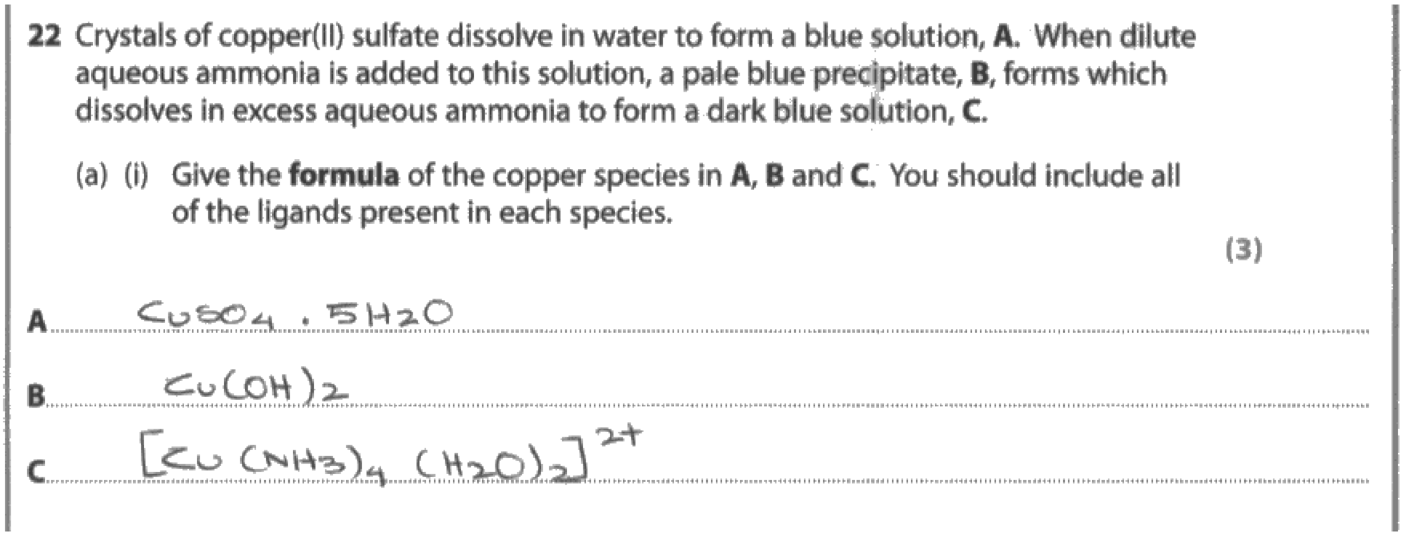
Examiner Comments

This has the correct answer for A, and also a good alternative correct answer for B, but C is not correct, as it has six ammine ligands rather than four. This was quite a common incorrect response.



22 Crystals of copper(II) sulfate dissolve in water to form a blue solution, **A**. When dilute aqueous ammonia is added to this solution, a pale blue precipitate, **B**, forms which dissolves in excess aqueous ammonia to form a dark blue solution, **C**.

(a) (i) Give the **formula** of the copper species in **A**, **B** and **C**. You should include all of the ligands present in each species.

(3)

A $CuSO_4 . 5H_2O$

B $Cu(OH)_2$

C $[Cu(NH_3)_4(H_2O)_2]^{2+}$

ResultsPlus

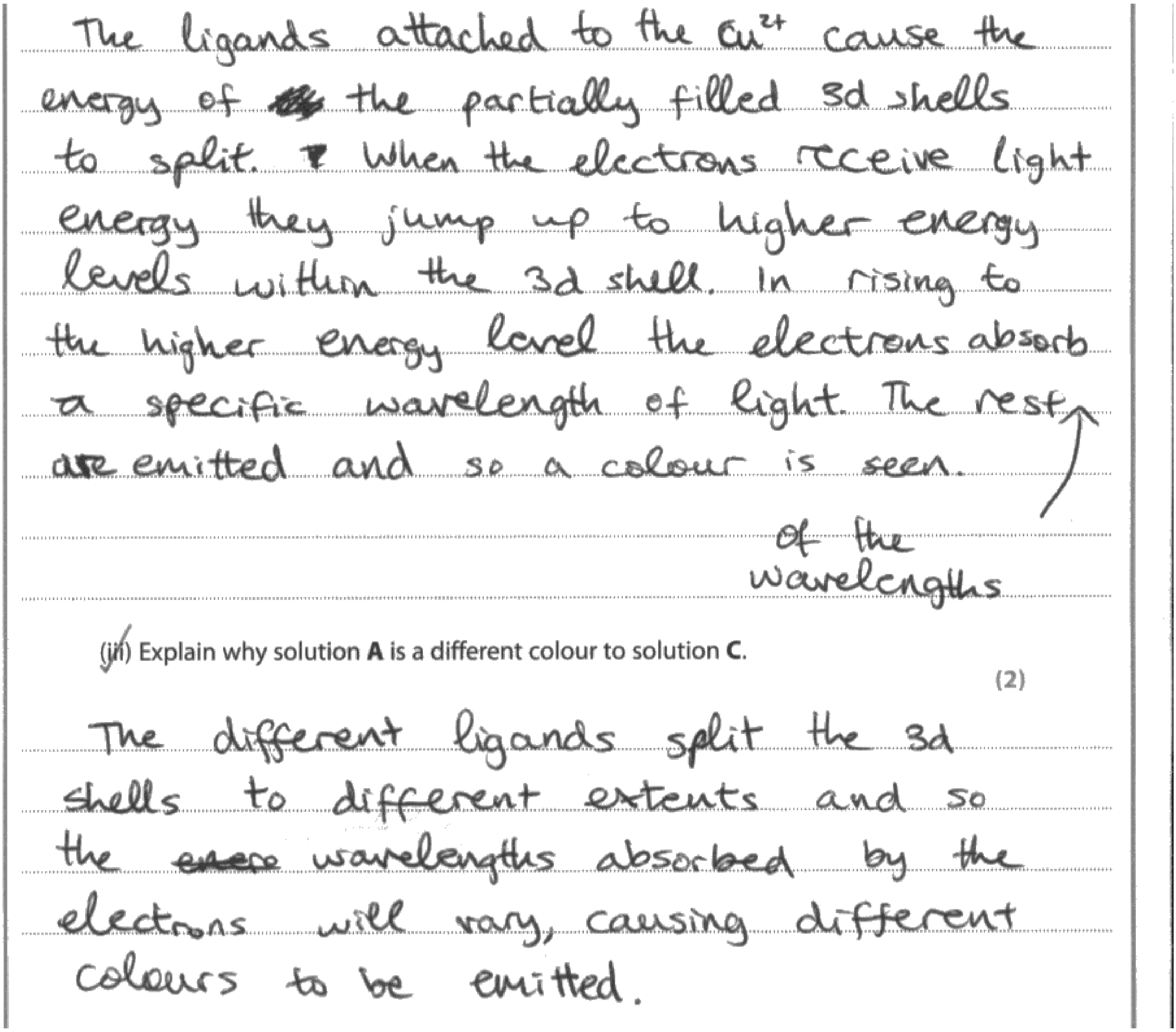
Examiner Comments

This candidate has identified the blue crystals of copper sulphate, having the formula given in A, however the question required the formula of the copper species in an aqueous solution of the crystals. B and C are both correct, and scored two marks.

Question 22 (a) (ii-iii)

The first part of this item has appeared in a number of different forms in recent examinations, and students have obviously prepared carefully for it. Fully correct answers were quite common, although there were still occasional mistakes with the numbers of orbitals and subshells which have been commented on in previous examiners reports. In particular the ligands will not split a single orbital or multiple subshells.

The second part of the question required careful application of ideas in the first and, although many candidates scored one mark, two here was relatively uncommon.



The ligands attached to the Cu^{2+} cause the energy of the partially filled 3d shells to split. When the electrons receive light energy they jump up to higher energy levels within the 3d shell. In rising to the higher energy level the electrons absorb a specific wavelength of light. The rest of the wavelengths are emitted and so a colour is seen.

(iii) Explain why solution **A** is a different colour to solution **C**.

(2)

The different ligands split the 3d shells to different extents and so the ~~enere~~ wavelengths absorbed by the electrons will vary, causing different colours to be emitted.

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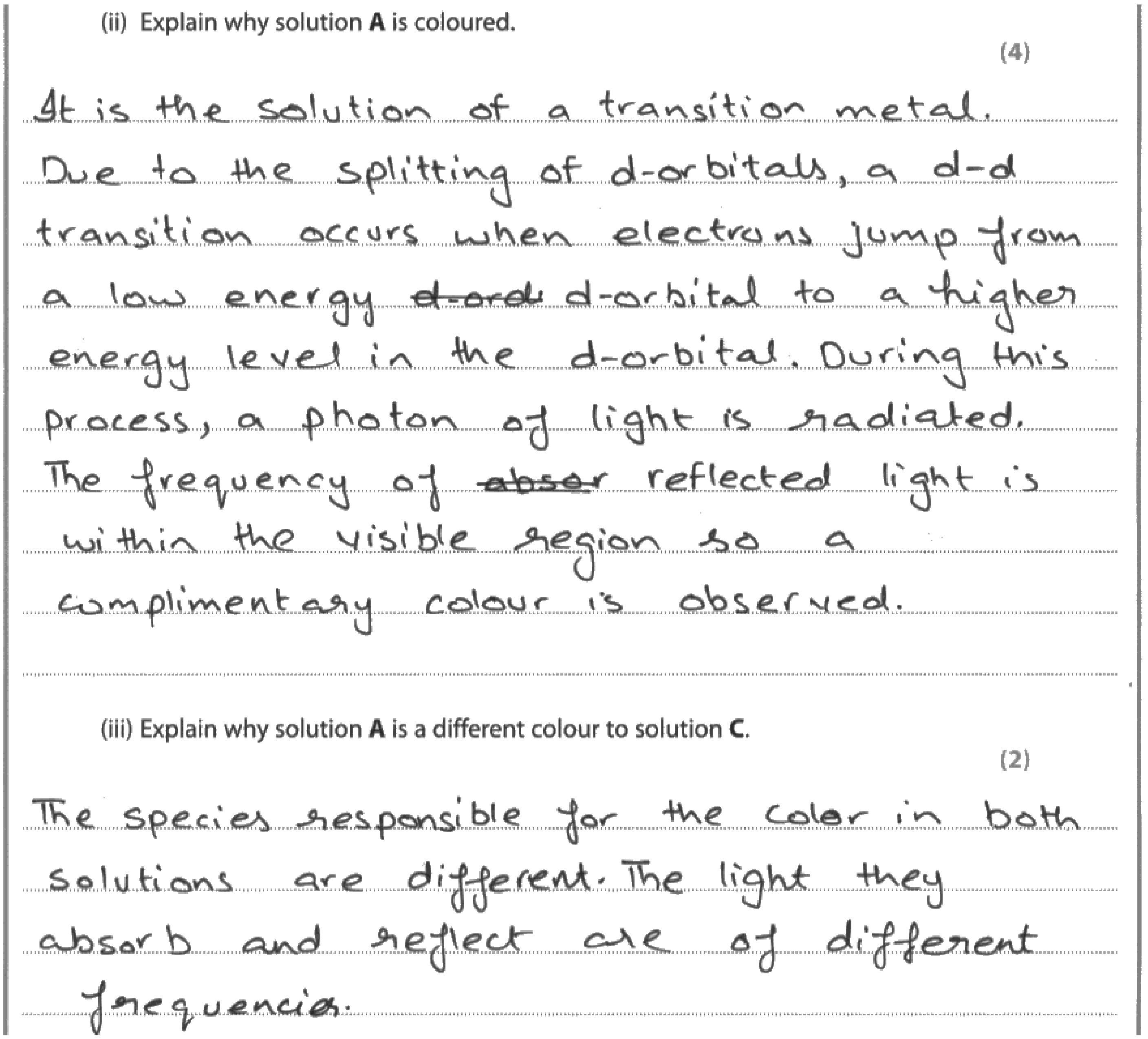
Examiner Comments

This is a good example of scoring both marks in part (a)(iii), although it only scored two marks in (a)(ii). The use of 3d shells is incorrect and so did not score marking point 1. The marks for promoting electrons from lower to higher energy levels and for absorbing light were both awarded, but unfortunately the candidate stated that light was emitted as the electrons returned to the lower energy level, and this did not allow this mark to be scored.


(ii) Explain why solution **A** is coloured.

(4)

It is the solution of a transition metal. Due to the splitting of d-orbitals, a d-d transition occurs when electrons jump from a low energy ~~d-ord~~ d-orbital to a higher energy level in the d-orbital. During this process, a photon of light is radiated. The frequency of ~~absor~~ reflected light is within the visible region so a complimentary colour is observed.

(iii) Explain why solution **A** is a different colour to solution **C**.

(2)

The species responsible for the color in both solutions are different. The light they absorb and reflect are of different frequencies.

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Examiner Comments

This second example makes an excellent attempt at 22(a)(ii), though unfortunately the electrons radiated energy rather than absorbing it so only scored three of the four available marks. In 22(a)(iii) one mark was scored for the different frequencies of light being absorbed and reflected.

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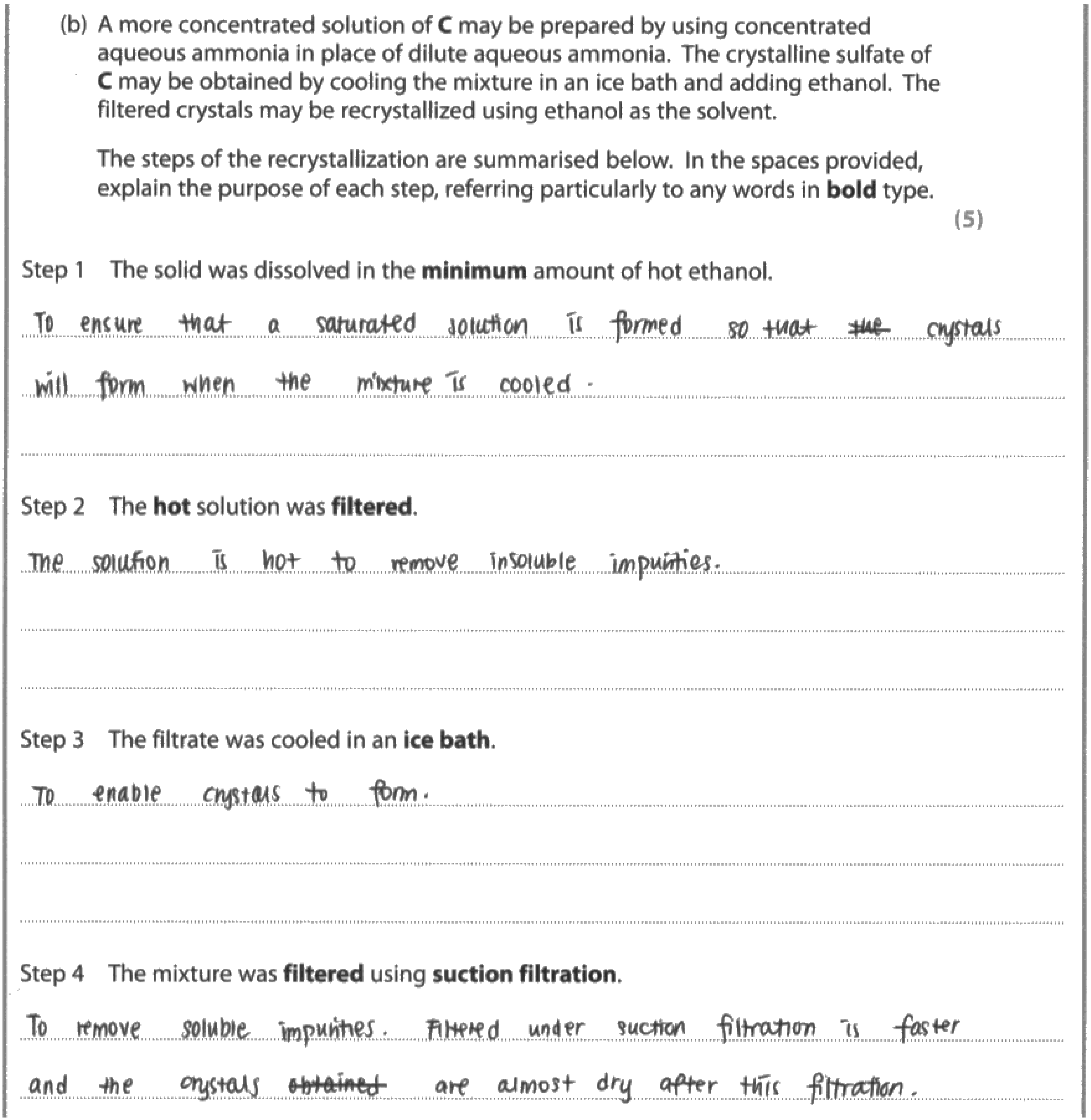
Examiner Tip

Use mark schemes and examiners reports to prepare carefully responses to questions which appear often in exams, of which this is an example.

Question 22 (b)

The ideas of a number of candidates did not gain full marks because they did not address all of the words in bold in this question. There were six marks available for the maximum score of five, with one mark linked to each of these words. The ideas removal of insoluble impurities in step 2 and soluble impurities in step 4 were well known, as was the idea that the suction filtration was faster or led to drier crystals. The other ideas, particularly the use of ice to maximise the amount of crystal formed, were less commonly seen by examiners.



(b) A more concentrated solution of **C** may be prepared by using concentrated aqueous ammonia in place of dilute aqueous ammonia. The crystalline sulfate of **C** may be obtained by cooling the mixture in an ice bath and adding ethanol. The filtered crystals may be recrystallized using ethanol as the solvent.

The steps of the recrystallization are summarised below. In the spaces provided, explain the purpose of each step, referring particularly to any words in **bold** type.

(5)

Step 1 The solid was dissolved in the **minimum** amount of hot ethanol.

To ensure that a saturated solution is formed so that ~~the~~ crystals will form when the mixture is cooled.

Step 2 The **hot** solution was **filtered**.

The solution is hot to remove insoluble impurities.

Step 3 The filtrate was cooled in an **ice bath**.

To enable crystals to form.

Step 4 The mixture was **filtered** using **suction filtration**.

To remove soluble impurities. Filtered under suction filtration is faster and the crystals ~~obtained~~ are almost dry after this filtration.

ResultsPlus

Examiner Comments

This candidate scored four marks. One in step 1 for the saturated solution. One in step 2 for removing insoluble impurities. Step 3 did not score anything, whilst step 4 scored two, one for the removal of soluble impurities and one for the faster filtration (or almost dry crystals).

Question 23 (a)

Most candidates were very familiar with this type of calculation. While the majority succeeded in scoring both marks, some did not read the question and took the third element as oxygen, whilst others gave the empirical formula as C_2H_5Cl, presumably because they recognised that this would form a sensible organic structure on its own, but the C_2H_4Cl perhaps would not. Nevertheless a very well answered question in general, with very many candidates setting out a clear method for their calculations.

Question 23 (b) (i)

Most who scored 2 marks in 23(a) were able to score this mark as well, although if an error had been made in 23(a) this question became very difficult.

Question 23 (b) (ii)

Amongst a variety of incorrect answers here, candidates employed isotopes of carbon and hydrogen to explain the three peaks. Of those who recognised that chlorine was responsible some incorrectly said that chlorine might have an isotopic mass of 36 or even 35.5.

Question 23 (b) (iii)

If candidates recognised the significance of chlorine in these questions they were able to recognise that the more abundant isotope of chlorine was chlorine-35.

Question 23 (b) (iv-vi)

This question proved extremely challenging for many candidates. Frustratingly some candidates gave good explanations but did not realise which structures were required and gave either the diol or sometimes the dichloro compounds. The logic behind the explanation was not often fully explained, causing candidates to drop one of the marks. Many candidates, however, clearly found following through the question extremely difficult and scored very few if any marks here.

The iodoform test was well known, with many candidates scoring here. Too often candidates' memory let them down, and they gave the formula of iodomethane, CH_3I, rather than triiodomethane CHI_3. Some did not read the question carefully enough and simply stated that this was the iodoform or triiodomethane *test*, without actually demonstrating that they knew that this was the yellow product. Many candidates, however, scored two marks here.

This also proved challenging for students who had not followed the earlier parts of the question. Many different compounds were suggested. Sadly, some candidates gave the correct name and an incorrect formula for the diol in the reaction, whilst others did the opposite. Very few candidates scored three marks.

*(iv) **Q** reacts with aqueous sodium hydroxide to form an organic compound, **R**.

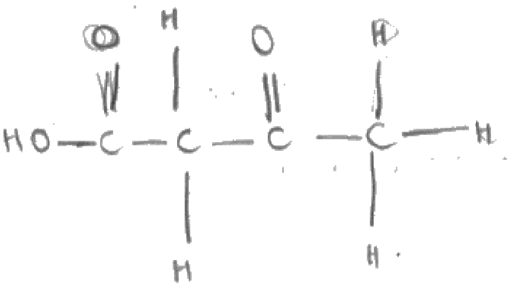
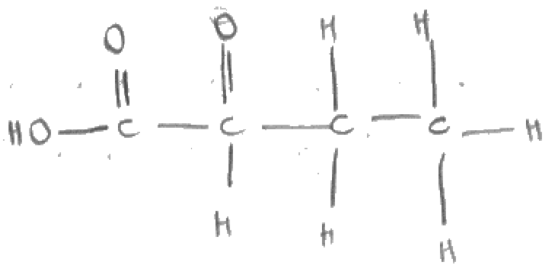
The functional groups of compound **R** are on different carbon atoms.

Compound **R** reacted slowly with sodium, producing a total of one mole of hydrogen gas per mole of **R**.

When compound **R** was heated under reflux with excess acidified sodium dichromate(VI), an organic compound, **S**, was formed.
Compound **S** reacted rapidly with sodium, producing a total of 0.5 mol of hydrogen gas per mole of **S**.

Draw the **displayed** formulae of the two possible structures for compound **S**.
Explain how your structures are consistent with these data.

(5)

	
Structure I	Structure II

Explanation

- since only 0.5 moles of H_2 gas is formed from S, we can assume that there should only be one 'COOH' group.
- initially Q exists as a dichlorine organic compound. Q is converted to a diol 'R'. since 1 mol of H_2 gas is formed per mole there should be 2 'OH' groups.
- R undergoes oxidation to form a ketone and a carboxylic acid.

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Examiner Comments

This candidate gives an excellent explanation, but unfortunately the carbon of the ketone group in Structure II has an extra hydrogen on an otherwise perfect structure, so one mark was dropped at this point.

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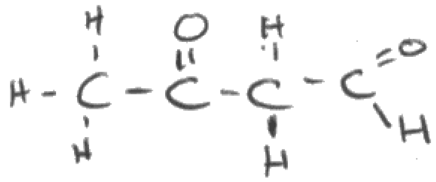
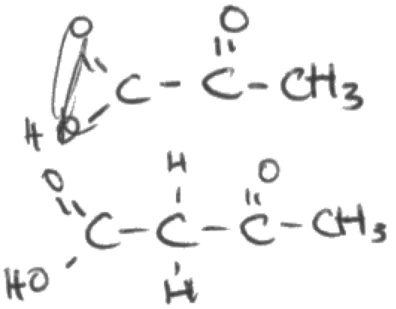
(5)



Structure I



Structure II

Explanation Q reacts with NaOH to form a diol R. The alcohol is reduced under reflux, producing a carboxylic acid. The carboxylic acid will react with the Na to form hydrogen. ~~[illegible]~~ but since 0.5 mol ~~the~~ of H_2 for only the must only be 1 COOH group.

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Examiner Comments

This response lacks clarity in the explanation and the alcohol is reduced rather than oxidised. It only scored one mark for the comment that R is a diol in the explanation. The diagram in Structure II is perfect, but Structure I has an aldehyde rather than a carboxylic acid group, and has the ketone on the same carbon as Structure II. Overall two marks were awarded.

Question 24 (a)

Many candidates were able to deduce the electrophile from the product structure.

This part proved more difficult with many identifying either $AlCl_3$ or $FeBr_3$ as being the organic source of the electrophile, rather than the expected 3-chloroprop-1-ene or the corresponding bromo- or iodo- compounds. Candidates were more likely to get the correct answer if they gave a structural formula than if they tried to name the compound, as there were frequently errors with the numbering of the position of the halogen or double bond.

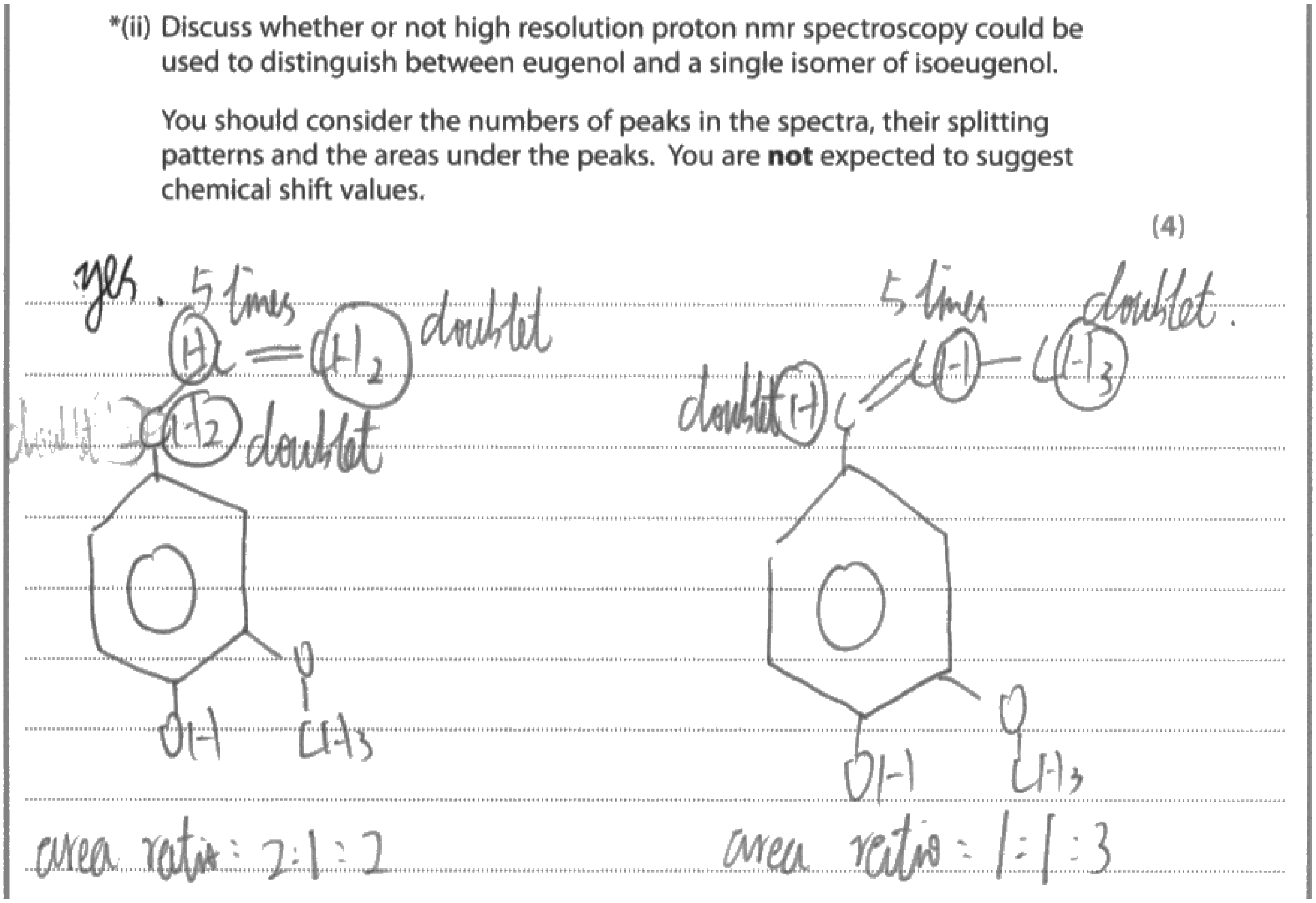
This question or its equivalent has been seen many times in the past, and candidates are well versed in giving the mechanism. There were still examples of the typical errors identified by the mark scheme, the most common of which was to omit the substituents not involved in the mechanism, thus losing the final mark.

Question 24 (b) (i)

This question was well answered by many, though optical isomerism was often suggested, and sometimes the explanation was not fully given. Many candidates referred to the restricted rotation around the double bond although the question wording clearly makes this irrelevant.

Question 24 (b) (ii)

NMR questions pose difficulties for some candidates, and this was a particularly tricky example. Far too few candidates appreciated that only the alkene side-chain was relevant to the discussion, an insight which made the question far more straightforward. Many candidates were able to score one mark for identifying eight environments, or two marks for the ratio of the areas in the two compounds, but surprisingly few scored more marks. Candidates found it very difficult to express with sufficient clarity the points they were trying to make to be awarded further marks. Those who drew diagrams or used the ones from earlier in the question had a structure to their answers which they found helpful, and which allowed them to score the mark for using the side chain or, if well labelled, for the splitting patterns or peak heights. Overall, this was a challenging question which differentiated at the higher levels.



*(ii) Discuss whether or not high resolution proton nmr spectroscopy could be used to distinguish between eugenol and a single isomer of isoeugenol.

You should consider the numbers of peaks in the spectra, their splitting patterns and the areas under the peaks. You are **not** expected to suggest chemical shift values.

(4)

yes. 5 lines

5 lines

area ratio: 2:1:2

area ratio: 1:1:3

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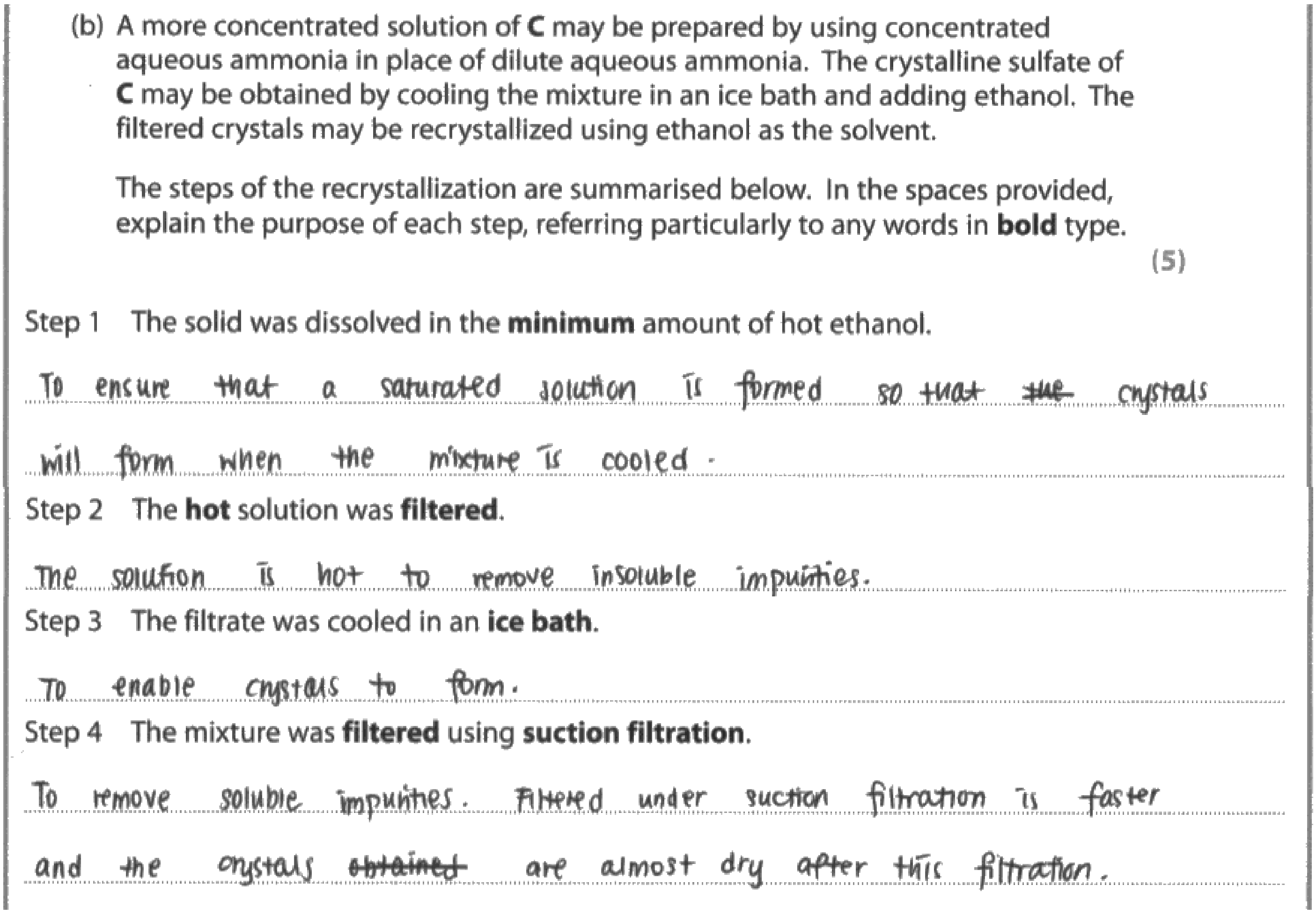
Examiner Comments

This is a very nice and succinct response which was awarded full marks. This demonstrates that the use of diagrams can sometimes be very advantageous.

Question 24 (b) (iii)

The idea that the V_2O_5 was acting purely as an active site heterogeneous catalyst was a common approach, as were general statements about the effect of a catalyst on the activation energy of a reaction. Some candidates did not read the question properly and made no effort to propose a mechanism.



(b) A more concentrated solution of **C** may be prepared by using concentrated aqueous ammonia in place of dilute aqueous ammonia. The crystalline sulfate of **C** may be obtained by cooling the mixture in an ice bath and adding ethanol. The filtered crystals may be recrystallized using ethanol as the solvent.

The steps of the recrystallization are summarised below. In the spaces provided, explain the purpose of each step, referring particularly to any words in **bold** type.

(5)

Step 1 The solid was dissolved in the **minimum** amount of hot ethanol.

To ensure that a saturated solution is formed so that ~~the~~ crystals will form when the mixture is cooled .

Step 2 The **hot** solution was **filtered**.

The solution is hot to remove insoluble impurities.

Step 3 The filtrate was cooled in an **ice bath**.

To enable crystals to form.

Step 4 The mixture was **filtered** using **suction filtration**.

To remove soluble impurities. Filtered under suction filtration is faster and the crystals ~~obtained~~ are almost dry after this filtration.

ResultsPlus

Examiner Comments

This answer is sufficient to score both marks.

Question 24 (b) (iv)

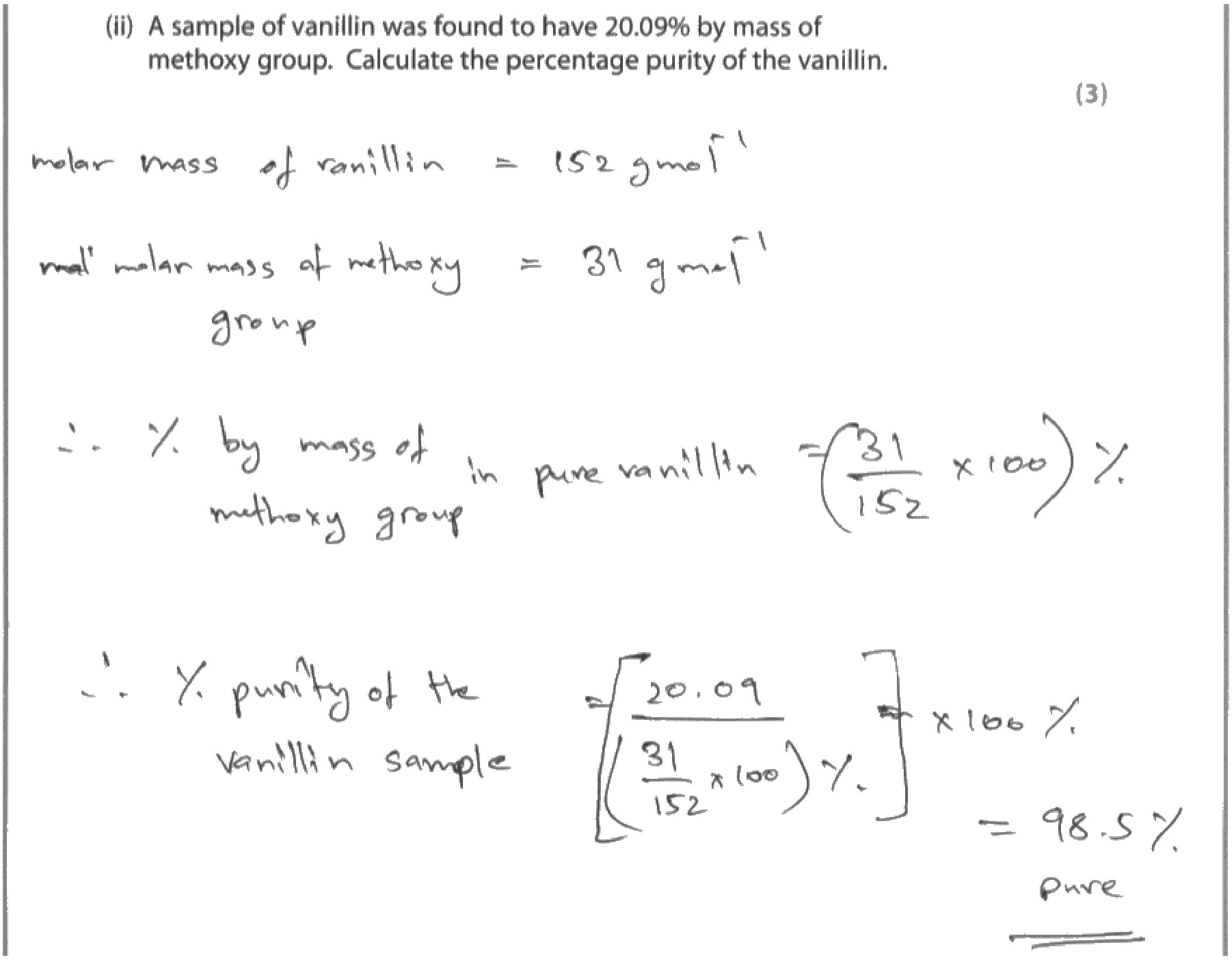
This was surprisingly poorly answered, with candidates often giving answers which suggested that they had not used the data book. Where ranges were identified, a justification for the technique not working was often correctly given.

Question 24 (c) (i)

Relatively few candidates were able to work through the ratios in the equations successfully, and some simply stated that the expected value would be six. Careful explanation of the answer was required, covering each step of the sequence.

Question 24 (c) (ii)

A surprisingly high number of candidates were unable to calculate the molar mass of vanillin. Only the better candidates were able to make a logical attempt at this non-standard calculation, although there were some excellent examples of all the routes given in the mark scheme.



(ii) A sample of vanillin was found to have 20.09% by mass of methoxy group. Calculate the percentage purity of the vanillin.

(3)

molar mass of vanillin = 152 g mol^{-1}

~~mol'~~ molar mass of methoxy group = 31 g mol^{-1}

$\therefore$ % by mass of methoxy group in pure vanillin $= \left(\frac{31}{152} \times 100\right)\%$

$\therefore$ % purity of the vanillin sample $= \left[\dfrac{20.09}{\left(\frac{31}{152} \times 100\right)\%}\right] \times 100\,\%$

$= 98.5\%$ pure

ResultsPlus
Examiner Comments

A very well laid out example of a fully correct calculation.

Paper Summary

Questions that were familiar to candidates from previous years, for example colour in complex ions and electrophilic substitution were generally answered well.

General advice :

- Carefully revise experimental techniques such as recrystallisation, making a standard solution or carrying out titrations. Questions on these types of activities appear often.
- Read questions carefully, especially those in Section C or questions set in an unfamiliar context. You may find highlighting or underlining helpful.
- Remember to include the electrons in half-equations. The two sides of a correct equation will have the same total charge.
- Label each step of a calculation to show clearly what you are attempting to work out and do not round intermediate values in multi step calculations; keep the current number in your calculator.

Grade Boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

http://www.edexcel.com/iwantto/Pages/grade-boundaries.aspx

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