Examiners' Report

June 2014

IAL Chemistry WCH06 01

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Introduction

The paper seemed to work well. Nearly all parts of questions were attempted. There was no evidence that candidates did not have time to complete the paper.

There were several rather different styles of question, which seemed to work very well. Candidates familiar with setting up experiments were able to handle them successfully.

There were many candidates who had been thoroughly prepared by their centres, and had carried out the practical work. This led to some good responses which was a privilege for examiners to see.

As a result there were many marks above 80% which was pleasing. At the same time, there were centres where the candidates showed little knowledge of practical aspects of the course, so their candidates received rather low marks.

Question 1 (a)

This was a gentle start which was answered successfully by nearly everyone. As usual with colour questions it was important to give one (correct) colour. Green was by far the most popular correct answer.

Answer ALL the questions. Write your answers in the spaces provided.

1   **H** is an aqueous solution of chromium(III) sulfate.

   (a) What is the colour of the solution?

   (1)

   Violet - Ruby

ResultsPlus
Examiner Comments

Notice how the candidate has given two colours, which was allowed for this combination on this occasion but it is not good practice.

ResultsPlus
Examiner Tip

When a colour is asked for, a single colour will always suffice.

Answer ALL the questions. Write your answers in the spaces provided.

1   **H** is an aqueous solution of chromium(III) sulfate.

   (a) What is the colour of the solution?

   (1)

   Orange

ResultsPlus
Examiner Comments

A common wrong answer caused by confusion with the dichromate(VI) ion.

Question 1 (b)

This proved more challenging. Few gave incorrect colours but the initial mark was often lost for first recognising that a precipitate was formed. There was often confusion as to what happens in excess sodium hydroxide. It is sad to see candidates giving the correct answers but losing marks by giving incorrect additional information. The question asked what you would see so formulae were not required but if given had to be correct.

(b) Describe what you would **see** when sodium hydroxide solution is added to **H**, drop by drop, until the sodium hydroxide is in excess.

(2)

First green precipitate that then dissolves to form green solution

ResultsPlus
Examiner Comments

An adequate fully correct answer.

(b) Describe what you would **see** when sodium hydroxide solution is added to **H**, drop by drop, until the sodium hydroxide is in excess.

(2)

It turns Green and it does not dissolve in excess NaOH

ResultsPlus
Examiner Comments

The first mark is lost as there is no mention of state. The second statement is untrue. If it had said 'it dissovles in excess sodium hydroxide' then the second mark would be given.

Question 1 (c)

In this question, a formula was required for the first mark. Though some answered correctly, there were many incorrect formulae. Most common was CrO_4^-, followed by various attempts at a dichromate(VI) ion. The reaction type was best described as what happened to chromium - oxidation, though redox was acceptable.

A surprising number of candidates introduced sulphate or iodide as their first answer.

(c) When hydrogen peroxide is added to the reaction mixture formed in (b), a yellow solution is formed.

Give the formula of the ion responsible for the yellow colour and state the type of reaction which has produced this ion.

(2)

Ion formula ...... CrO_4^{2-}

Reaction type ...... Reduction

ResultsPlus
Examiner Comments

The question has not been read sufficiently carefully.

To produce this ion chromium has been oxidized.

ResultsPlus
Examiner Tip

Read the question twice (RTQ[2]).

(c) When hydrogen peroxide is added to the reaction mixture formed in (b), a yellow solution is formed.

Give the formula of the ion responsible for the yellow colour and state the type of reaction which has produced this ion.

(2)

Ion formula ...... CrO_4^-

Reaction type ...... oxidation

ResultsPlus
Examiner Comments

This formula for the ion was the most common error.

A little thought would show this is extrmely unlikely as chromium only has six outer shell electrons.

ResultsPlus
Examiner Tip

Check each answer for errors like this.

Question 2 (a)

The first two parts of this question did not trouble those experienced in the practical work.

(a) This produced the full range of marks from 0 to 4 with almost equal frequency. There were instructive errors in each piece of apparatus. It was common to see platinum electrodes in either or both of the half cells. On this occasion charges on electrodes or the wrongly named cathodes and anodes were ignored but candidates need to be careful in future to give such information correctly. The salt bridge needed to be filter paper soaked in solution C or saturated potassium nitrate solution. Of course a tube of saturated potassium nitrate solution in agar gel would work but was not given in the listed available apparatus. The high resistance voltmeter or X needed to be connected between the two electrodes. Other instruments were chosen, often in combination. Additional power supplies were included. None of which were acceptable.

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2 A student wishes to measure the E_{cell} value of an electrochemical cell in which the following reaction occurs.

$$Fe(s) \quad + \quad Cu^{2+}(aq) \quad \rightarrow \quad Fe^{2+}(aq) \quad + \quad Cu(s) \quad \textbf{Equation 1}$$

The solutions and apparatus available to the student are listed below.

Solution **A**: copper(II) sulfate 1.00 mol dm^{-3}
Solution **B**: iron(II) sulfate concentration unknown
Solution **C**: potassium nitrate saturated
Solution **D**: barium chloride saturated

Copper foil electrodes
Iron foil electrodes
Platinum foil electrodes

Voltmeter **W**: low resistance
Voltmeter **X**: high resistance
Ammeter **Y**: low resistance
Ammeter **Z**: high resistance

Beakers
Connecting leads
Crocodile clips
Strips of filter paper

(a) Draw a labelled diagram of the cell that the student should set up to measure E_{cell} for the reaction in **Equation 1**.

Only use items selected from the list above.

(4)
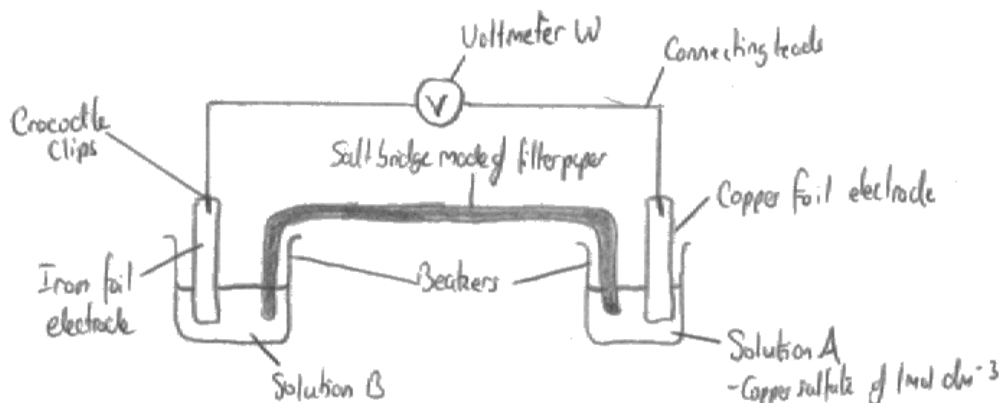
Question 2 (b)

(b) The first part, (i), was fairly straightforward, though about half the candidates made errors. Answers of +0.45 V and +1.13 V were common.

(ii) This novel calculation was surprisingly well done. As often happens, candidates who reduced the number of significant figures before the end of the question got the wrong final answer and lost a mark. Many others did not know how to invert a natural logarithm, and simply took the natural logarithm. Some chose to use the inverse of $\log_{10}$.

(b) (i) The student measured E_{cell} as +0.79 V. The electrode dipping into the copper(II) sulfate solution was the positive electrode.

For this half-reaction

$$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s) \qquad E^{\ominus} = +0.34\,V$$

where $E^{\ominus}$ is the **standard** electrode potential.

Use the above information to calculate the electrode potential (E) in the student's cell for the half-reaction

$$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$$

(2)

$\therefore E^{\circ}cell = +0.34 - x$
$+0.79 = +0.34 - x$
$+0.45 = -x$
$x = -0.45v \quad \therefore E^{\ominus} = -0.45v$

(ii) For the half-reaction

$$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s) \qquad E^{\ominus} = -0.44\,V$$

where $E^{\ominus}$ is the **standard** electrode potential.

For this half-reaction, the electrode potential (E) at a particular concentration is related to the standard electrode potential ($E^{\ominus}$) by the equation

$$E = E^{\ominus} + 0.013 \ln [Fe^{2+}] \qquad \textbf{Equation 2}$$

where ln is the natural logarithm and $[Fe^{2+}]$ is the concentration of Fe^{2+} ions in mol dm^{-3}.

Use **Equation 2**, and your answer to (b)(i), to calculate the concentration of Fe^{2+} ions in solution **B**.

(2)

$-0.45 = -0.44 + 0.013 \ln [Fe^{2+}]$
$-0.023 = \ln[Fe^{2+}] \quad \therefore 0.023 = -\ln[Fe^{2+}]$
$[Fe^{2+}] = -\log(0.023) = 1.64 M.$

ResultsPlus
Examiner Comments

The first part is fine.

The second part gets the wrong value for ln[Fe2+] and gets no transferred error as they should get 0.977 mol dm^{-3}.

ResultsPlus
Examiner Tip

It is worth continuing answering a question, even if you think you may have have made a mistake.

To go find x from ln x, use the e^x button on your calculator.

Question 2 (c)

This was on more familiar ground.

In part (i) the calculation of the titres was correct but many chose to choose the non-concordant result of 22.80 in their mean calculation. Transferred errors from erroneous results were allowed, as usual.

(ii) This was surprisingly difficult. Many attempted to give the colour at the end point, when the colour change at the end point was clearly needed.

(iii) Despite being given the left hand side of the reaction equation (given to try to reduce consequential errors later), the completion of the equation was challenging. The final oxidation of manganese was not well known, though the simple rule that the stable lower oxidation state after chromium in the first transition series is +2 should have helped.

(iv) The calculation of concentration of the iron(II) sulfate was successfully achieved by 80% of candidates. Again, candidates who reduced the number of significant figures before the end of the question got the wrong final answer and lost a mark. Some muddled the titre and pipette volumes in the first and last steps. Some divided by five instead of multiplying by five. There were some candidates who rewrote the left hand side of the reaction equation, which is not a good idea.

(v) Some misread the question and did not calculate the percentage **difference**, but generally answers were consistently with correct answers part (iv).

(vi) The error in the pipette was usually correctly calculated, though some chose to double or treble the accuracy value. The common error in the burette calculation was to fail to multiply the accuracy by two. It was also common to see the pipette volume used, rather than the mean titre, in the burette calculation.

(vii) The term 'comment on' is important and means 'relate your knowledge of chemistry' to the values. Some statement relating to the percentage difference to the apparatus uncertainty was required.

(viii) There were many nebulous answers about measurements here. Less than half the candidates realised that iron(II) would be oxidized by oxygen in air, which is surprising, as this is a common problem with lower oxidation states of transition elements.

(c) The concentration of another solution of iron(II) sulfate, **Q**, was found by titration. 25.0 cm³ samples of **Q** were titrated with a solution of acidified potassium manganate(VII), concentration 0.0300 mol dm⁻³.

The results are as follows:

Titration	Rough	1	2	3
Burette reading (final) / cm³	25.00	24.40	24.40	25.70
Burette reading (initial) / cm³	1.00	2.10	1.60	3.30
Titre /cm³	24.00	22·30	22.80	22.40
Titres used to calculate mean (✓)		✓	✓	✓

(i) Complete the table and calculate the mean titre. Indicate with a (✓) the titres that you have used in your calculation.

(2)

Mean titre $\frac{22.3 + 22.8 + 22.4}{3}$ = 22.5 cm³

(ii) State the colour change at the end-point.

(1)

Pink to colourless

(iii) Complete the equation for the reaction occurring during the titration. State symbols are not required.

(2)

$MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow$ 5 ~~4~~ Fe³⁺ O₃H₃ + Mn²⁺O

(iv) Calculate the concentration, in mol dm⁻³, of the iron(II) sulfate solution, **Q**.

Give your answer to **three** significant figures.

(4)

$Mn : Fe$
$1 : 5$

$conc = 0.03 \ mol \ dm^{-3}$
$vol = 22.5 \ cm^3 = 0.0225 \ dm^3$
$mol = conc \times vol = 0.03 \times 0.0225$
$= 6.75 \times 10^{-4} \ mol$

$mol \ of \ Fe = 6.75 \times 10^{-4} \times 5$
$= 3.375 \times 10^{-3}$

$vol = 25 \ cm^3 = 0.025 \ dm^3$

$conc = \dfrac{3.375 \times 10^{-3}}{0.025} = 0.135 \ mol \ dm^{-3}$

(v) The concentration of the iron(II) sulfate solution, **Q**, was also measured on a previous day using the method described in part (a).

The concentration was found to be 0.157 mol dm⁻³.

Calculate the percentage difference between this value and the value you calculated in (c)(iv). You should assume that the correct concentration is 0.157 mol dm⁻³.

(1)

$0.157 - 0.135 = 0.022$

$\dfrac{0.022}{0.157} \times 100 = 14.0 \%$

(vi) In the titration, the volume delivered by the pipette is accurate to ±0.06 cm³. Each burette reading is accurate to ±0.05 cm³.

Calculate the percentage error of the pipette for a volume of 25.00 cm³ and of the burette for your mean titre.

(2)

$$\frac{0.06}{25} \times 100 = 0.24\%$$

$$\frac{0.05}{22.5} \times 100 =$$

Pipette .... ±0.24%

Burette .... ±0.22%

(vii) Comment on the magnitudes of the values you have calculated in (c)(v) and (c)(vi).

(1)

My value for (v) was over 9%, which ~~that~~ suggests that there were external factors that changed the result of the test. My values for (vi) are low, as the ~~precision~~ ~~accuracy~~ of my apparatus was suited for the measurements

(viii) Suggest why the concentration of iron(II) sulfate in solution **Q** calculated in (c)(iv) is lower than the value given in (c)(v).

(1)

Parallax error caused by the experimenter not having his eyes levelled with the measuring apparatus, the burette could have caused the reading for the titre to be lower than the actual amount.

Question 3 (a) (i)

The test with Brady's reagent was well known with very few candidates giving an incorrect answer to part (a)(i). There were some who omitted the state of the product.

Question 3 (a) (ii)

In part (ii) it was best to say that G is an aldehyde or ketone, though 'it is a carbonyl compound' was accepted. Just 'contains C=O' was insufficient as this includes many other compounds.

Question 3 (b) (i)

The result of the Tollens' test in (b)(i) was remembered well, but the chemicals and conditions gave problems.

The usual method to make Tollens' reagent is to add a few drops of sodium hydroxide to silver nitrate solution to form a precipitate of silver oxide which dissolves as ammonia solution is added. It was not necessary to mention the sodium hydroxide this time.

The condition of heat was dependent on the correct reagents. Heat under reflux was not acceptable.

(b) Substance **G** is tested with Tollens' reagent. The test is **negative**.

   (i) Identify the solutions used to make Tollens' reagent.

      What condition is essential for this test to work?

      What would you see when a **positive** result is obtained?

(4)

Solutions *Silverchloride, and ammonia solution*

Condition *alkaline*

Positive result *silver mirror on the walls of the test tube.*

ResultsPlus
Examiner Comments

This is an interesting answer.

Silver chloride with ammonia might work, but it is not Tollens' reagent.

Heat is not mentioned so the third mark is lost.

The formation of a silver mirror is described well.

ResultsPlus
Examiner Tip

Learn how to make up important solutions, like Tollens' reagent.

Question 3 (b) (ii)

The name of the group 'ketone had to be given in (ii) as the question did ask for the **name** of the functional group.

Question 3 (c) (i)

Like part (a)(i) the positive result of the iodoform test was well known, though again some omitted the state.

Question 3 (c) (ii)

The significance of the postive iodoform test was not well known. 'Methyl ketone' was the correct deduction within the context of this question.

Question 3 (d)

This produced all marks between 0 and 3 with almost equal frequency. The first mark was easiest to achieve, though many gave 'one environment' alone which was penalised. The second mark was more rarely awarded, despite two answers being acceptable. The significance of the lack of splitting was the best way forward. The third mark was more straightforward.
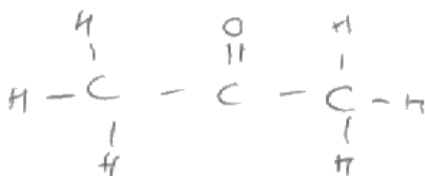
(d) The high resolution nmr spectrum of **G** is shown below.
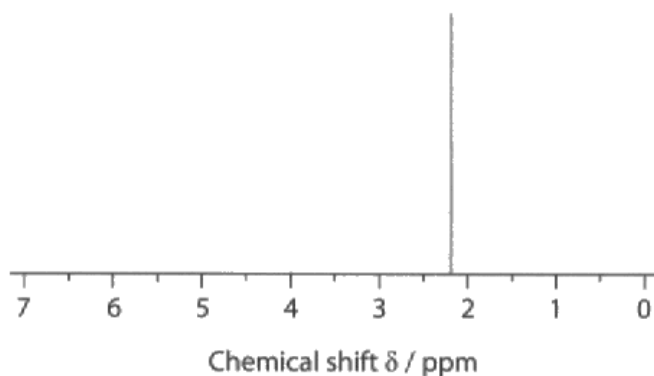
Chemical shift δ / ppm

Give **two** pieces of information about substance **G** that can be deduced from this spectrum. Use this information and your previous deductions to draw the displayed formula of **G**.

(3)

as it only has one peak^(singlet), there must be an OH group bonded to the carbon atoms, in the centre of the molecule.

Displayed formula of **G**:


ResultsPlus
Examiner Comments

This is a fairly typical response of an E grade candidate.

They deduced the formula correctly, but were unable to explain the significance of the single peak in the spectrum.

ResultsPlus
Examiner Tip

Know that the number of peaks is related to the number of hydrogen envirnoments and how the splitting depends on the numbers of hydrogens on adjacent carbons.

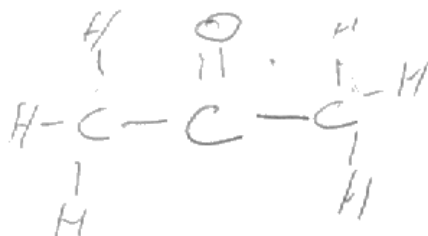(d) The high resolution nmr spectrum of **G** is shown below.
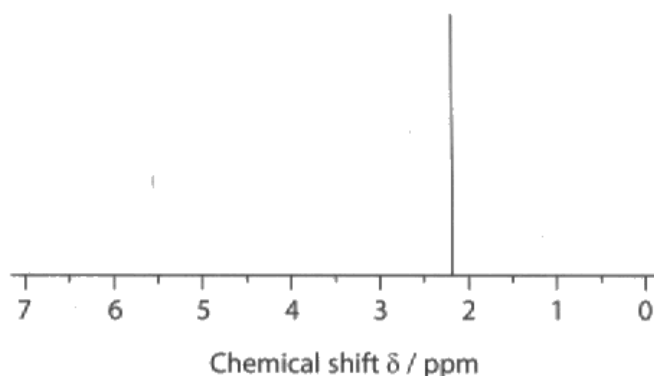
Chemical shift δ / ppm

Give **two** pieces of information about substance **G** that can be deduced from this spectrum. Use this information and your previous deductions to draw the displayed formula of **G**.

(3)

There is only one proton environment and a C=O bond is present.

Displayed formula of **G**:

Question 3 (e) (i)

This had been asked on a previous occasion and was often correctly answered. Spurious or irrelevant advantages were often given like 'more efficient, 'more effective', or 'increases yield'. The key advantages are that it is faster and produces a drier product.
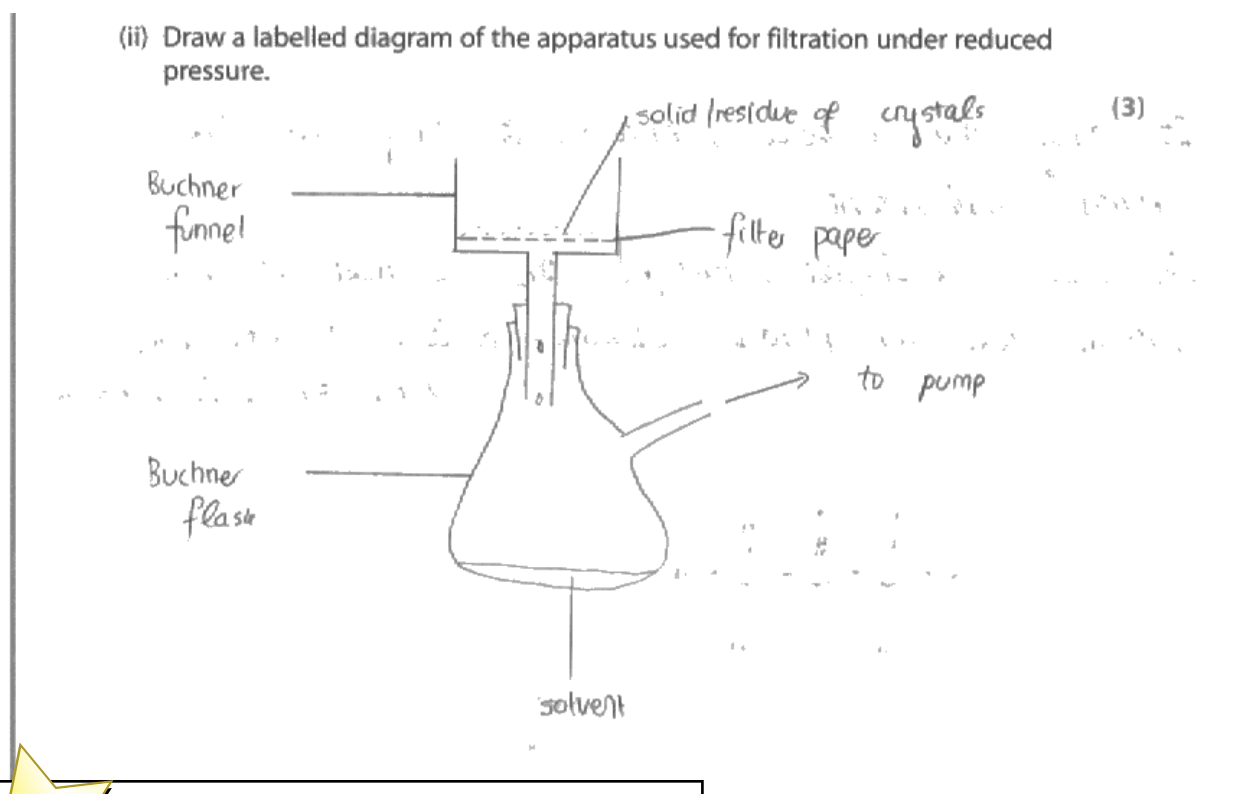
Question 3 (e) (ii)

Though this type of question has been asked before, it was surprisingly badly done.

Side-arm flasks are clearly unfamiliar.

The need for a pump and a seal between the Buchner funnel and the flask was not recognised.

The problem was the lack of a seal. Some connected a tap directly to the side-arm.

Hirsch funnels were an alternative to Buchner funnels of course, but in both the filter paper needed to be labelled and horizontal. Sintered glass is of course an acceptable alternative as a filter in the funnel if labelled as such.

(ii) Draw a labelled diagram of the apparatus used for filtration under reduced pressure.
(3)

solid /residue of crystals

Buchner funnel

filter paper

to pump

Buchner flask

solvent

ResultsPlus
Examiner Comments

This is a good simple diagram.

The candidate has been slightly fortunate, as the seal is not perfect - part of the bung is missing, but this was deemed sufficient.

Question 3 (e) (iii)

A familiar question, this produced a full range of marks with equal frequency.

In the dissolving step the' minimum volume' of 'hot' qualifications of the solvent were often missed from the first marking point.

The hot filtering step was often omitted, or misunderstood as removing soluble rather than insoluble impurities from the second marking point, as were the need for cooling for the second marking point.

The subsequent filtering was also omitted, as was the qualification of the washing solvent as 'cold' and 'minimum volume' for the third marking point.

In the final marking point candidates often failed to say how they would dry the product or decided to add an anhydrous substance to the product.

There were many muddled and jumbled answers, repeating steps like heating, filtering, washing and drying. Some even dried the filtrate.

There were also very weak answers which muddled liquid and solid purification methods often referring to both.

solution. Use sodium sulphate to ~~~~ dehydrate the products. When filtering make sure non of the solid passes through. And make sure you filter under reduced pressure as it will be more efficient. and easy to filter use a water jacket to maintain the temperature in the tube. And pass the water in the opposite direction ~~~~ ~~~~ ~~~~ ~~~~ to the flow of the products in the tube. Make sure that the flask which is used to collect the products is formed is closed completely; so that the solvent ~~ the product cannot move out of the flask. Use a to close it from the top.

ResultsPlus
Examiner Comments

A very weak and muddled response, the canididate confuses solid and liquid purifications.

Learn the verbs for the purificaton af a solid and a liquid.

ResultsPlus
Examiner Tip

For a solid; dissolve, filter hot, cool, filter wash and dry. Then hang the detail on them.

Question 3 (e) (iv)

Common errors were to measure the boiling temperature or check the melting point of the ketone, rather than the derivative, in a data book.

Checking data using the internet was allowed, though in future perhaps 'check with a reliable internet site' will be required.

(iv) How would you use the purified product to confirm the identity of **G**?
Practical details are not required.

(2)

Place the product in a ~~small~~ capillary tube and test for the boiling temperature. The temperature should be sharp and match the values in litterature.

Paper Summary

Advice to candidates

Treat practical work in the same way as theory. Learn the work thoroughly, including reasons for methods used.

- Read the question.

- Practice calculations.

- Do not round up numbers to the correct number of significant figures before the final answer. Remember **NAUTE**, no approximations until the end.

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