Examiners' Report
June 2017

IAL Chemistry WCH06 01

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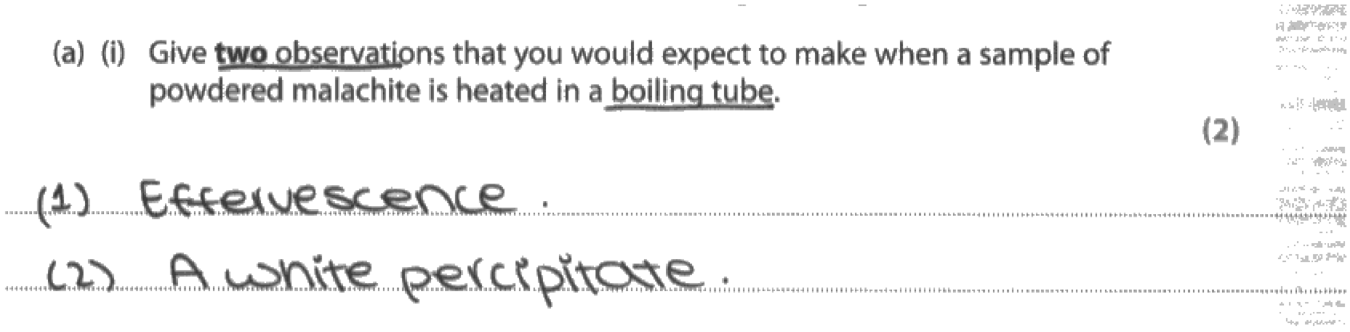
Introduction

This paper is primarily designed to assess practical knowledge as far as this is possible with a written paper, but candidates found questions which centred on laboratory situations the most demanding, particularly when in unfamiliar contexts. Candidates often seemed to rush into answers without clearly identifying what the question required and without taking the time to construct a logical response. The basic skills of plotting graphs using appropriate scales and then interpreting the results were generally not at the expected standard for advanced level candidates.

Question 1 (a) (i)

Few candidates gave a sensible observation indicating the formation of water, often simply re-stating the information given in the equation or suggesting that effervescence would be seen. While most realised that there would be a solid residue, the copper(II) oxide was often thought to be white or red. The use of the word ‘precipitate’ as though it was synonymous with solid was not penalised, but it should be avoided.



(a) (i) Give two observations that you would expect to make when a sample of powdered malachite is heated in a boiling tube.

(2)

(1) Effervescence.

(2) A white percipitate.

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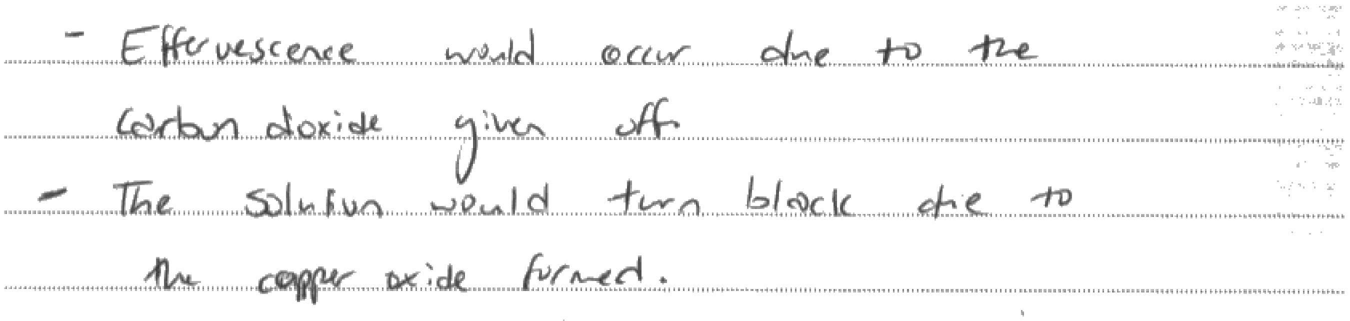
Examiner Comments

This response scored zero. The use of 'effervescence' should only be used when referring to the evolution of a gas from a liquid and copper(II) oxide is a black solid.



- Effervescence would occur due to the carbon dioxide given off
- The solution would turn black due to the copper oxide formed.

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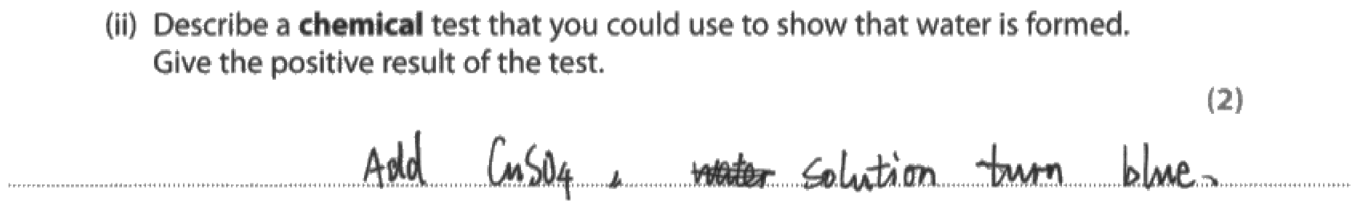
Examiner Comments

Effervescence is only appropriate when a gas is evolved from a solution so it is incorrect here. Similarly, 'solution turns black' cannot score the mark. There is no solution and it does seem that the candidate thinks copper(II) oxide is soluble.

Question 1 (a) (ii)

The standard tests for water were very well known, with transposition of colours and the use of ‘cobalt paper’ being common minor errors. Few candidates ignored the stipulation for a chemical test and suggested measuring the boiling temperature.



(ii) Describe a **chemical** test that you could use to show that water is formed.
Give the positive result of the test.

(2)

Add $CuSO_4$, ~~water~~ solution turn blue.

ResultsPlus
Examiner Comments

Because copper(II) sulfate is such a familiar compound, candidates needed to make clear the colour change of white to blue. The inappropriate use of 'solution' places the reagent mark at risk, although it was awarded here.

ResultsPlus
Examiner Tip

Aim to use chemical terms precisely.

Question 1 (a) (iii)

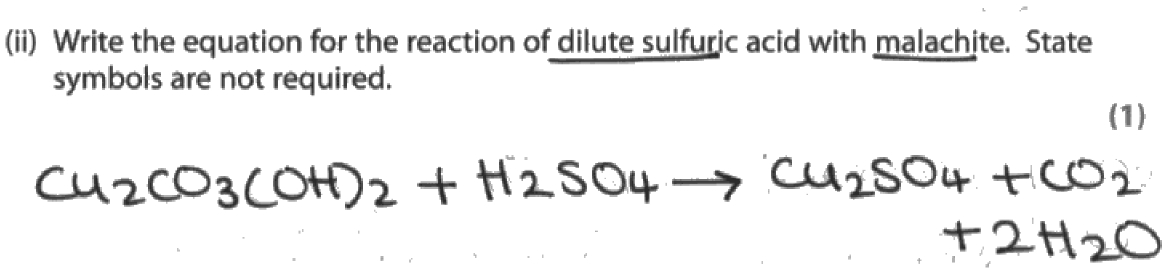
Almost all candidates scored full marks for the test for carbon dioxide.

Question 1 (b) (i)

The effervescence mark was usually scored but the second mark proved much less accessible, with ‘blue precipitate’ or just ‘dissolves’ being the most common attempts.

Question 1 (b) (ii)

Writing this equation proved quite a challenge. A wide range of products was suggested and those candidates who appreciated that the carbonate and the hydroxide would both react, often could not balance the equation.



(ii) Write the equation for the reaction of dilute sulfuric acid with malachite. State symbols are not required.

(1)

$Cu_2CO_3(OH)_2 + H_2SO_4 \rightarrow Cu_2SO_4 + CO_2 + 2H_2O$

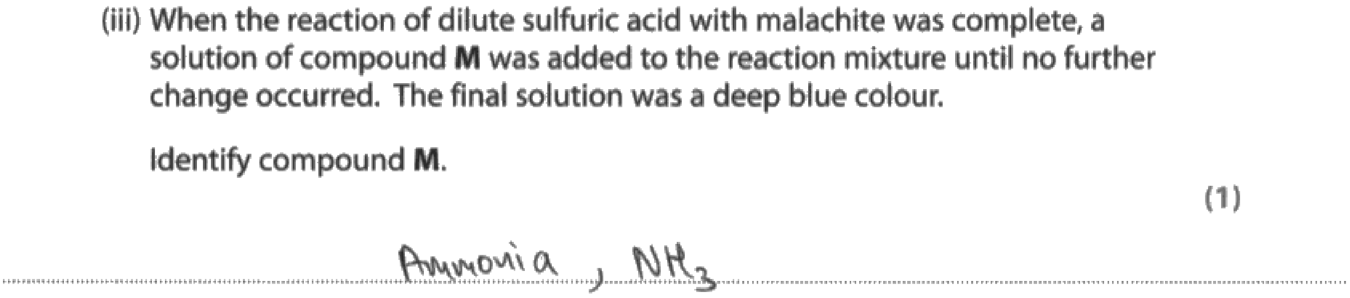
ResultsPlus

Examiner Comments

It was quite a common error to give the product of this reaction as copper(I) sulfate. It is unclear whether the candidates believed the copper in malachite to be in the +1 oxidation state or this to be a redox reaction.

Question 1 (b) (iii)

Ammonia was correctly identified by most candidates and the most common error was to give the formula of the tetraamminecopper(II) complex.



(iii) When the reaction of dilute sulfuric acid with malachite was complete, a solution of compound **M** was added to the reaction mixture until no further change occurred. The final solution was a deep blue colour.

Identify compound **M**.

(1)

Ammonia , NH_3

ResultsPlus

Examiner Comments

The command word 'identify' indicates that the name or the formula may be used. Here the candidate gives both. To secure the mark, both must be correct.

Question 1 (c) (i)

Most candidates were able to suggest a suitable substance to absorb water although inappropriate compounds such as copper(II) sulfate and cobalt(II) chloride were quite popular alternatives.

Question 1 (c) (ii)

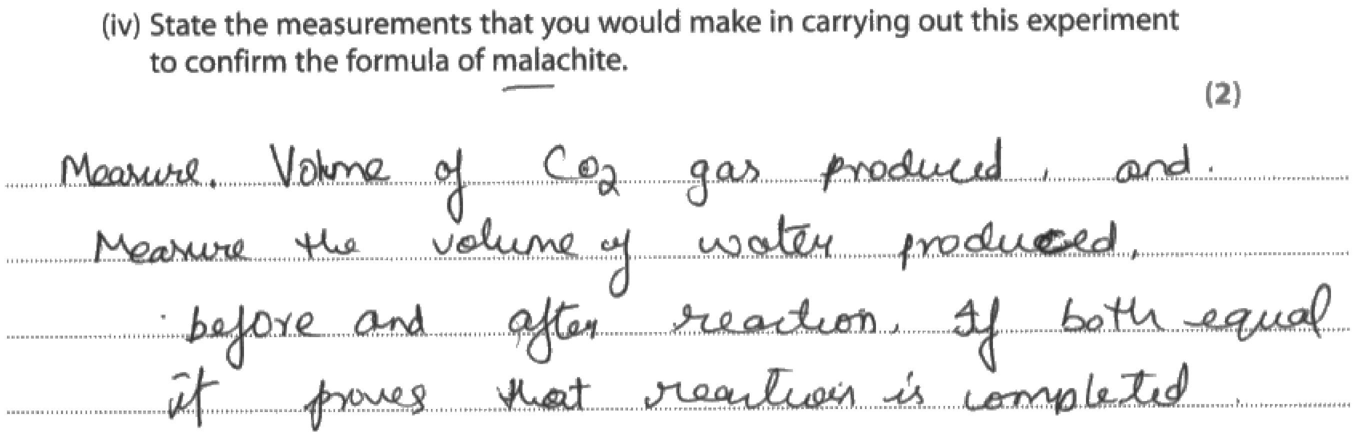
Many candidates who did not know about soda lime, realised that a strong alkali was needed and suggested one of the allowed alternatives.

Question 1 (c) (iii)

This question and 1(c)(iv) demonstrated a generally poor understanding of how the experiment would work. This led to many responses along the lines that no further reaction would occur. The standard response 'heat to constant mass' was only awarded if the malachite was specified in some way.

Question 1 (c) (iv)

This item was rather better answered than 1(c)(iii) but many candidates missed the point in some way. While measuring the change in mass of X and Y was required, measuring the change in mass of malachite would not provide additional information. The term 'amount' was used in an unclear way; in chemistry amount of a substance refers to moles and this cannot be measured directly so is inappropriate here. There were numerous references to measuring the volume of carbon dioxide in a syringe, suggesting an entirely different experiment.



(iv) State the measurements that you would make in carrying out this experiment to confirm the formula of malachite.

(2)

Measure. Volume of CO_2 gas produced, and.
Measure the volume of water produced,
before and after reaction. If both equal
it proves that reaction is completed.

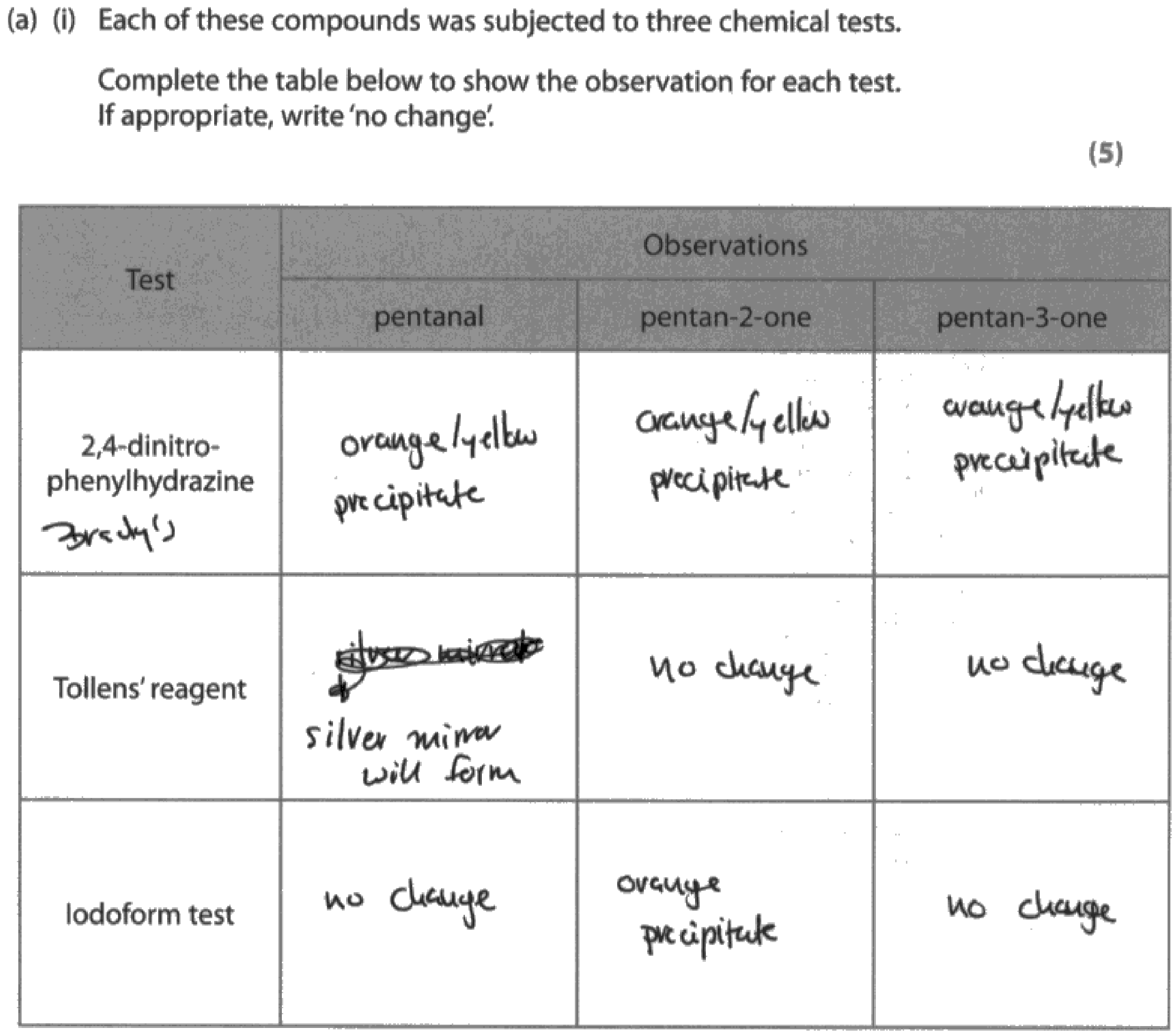
ResultsPlus

Examiner Comments

This was a fairly typical incorrect response, which does not refer to the experiment described in the question.

Question 2 (a) (i)

Many candidates scored full marks on this question , the most common loss of a single mark was showing pentanal giving a positive iodoform test. At the other end of the range, candidates referred to the positive result of a Brady's reagent test as a solution and confused Tollens' reagent and Fehling's solution.



(a) (i) Each of these compounds was subjected to three chemical tests.

Complete the table below to show the observation for each test.
If appropriate, write 'no change'.

(5)

Test	Observations		
	pentanal	pentan-2-one	pentan-3-one
2,4-dinitro-phenylhydrazine Brady's	orange/yellow precipitate	orange/yellow precipitate	orange/yellow precipitate
Tollens' reagent	~~[illegible]~~ silver mirror will form	no change	no change
Iodoform test	no change	orange precipitate	no change

ResultsPlus
Examiner Comments

A good response apart from describing iodoform crystals as orange. Yellow was acceptable but pale yellow preferred. This response scored 4 marks.

Question 2 (a) (ii)

The essential features of the iodoform test were well known although the third mark eluded many, often because they used the standby conditions of ‘heat under reflux’. A small number of candidates used the potassium iodide and sodium chlorate(I), with a few managing to confuse the two methods.

Question 2 (b)

There were many excellent answers but some candidates, who presumably did understand the technique, lost two marks by not identifying the proton environments on the structures. The use of skeletal formulae proved challenging for some candidates who either omitted the aldehyde proton or identified the ketone carbonyl group as having a proton.

Question 3 (a) (i)

Almost all candidates identified the voltmeter.

Question 3 (a) (ii)

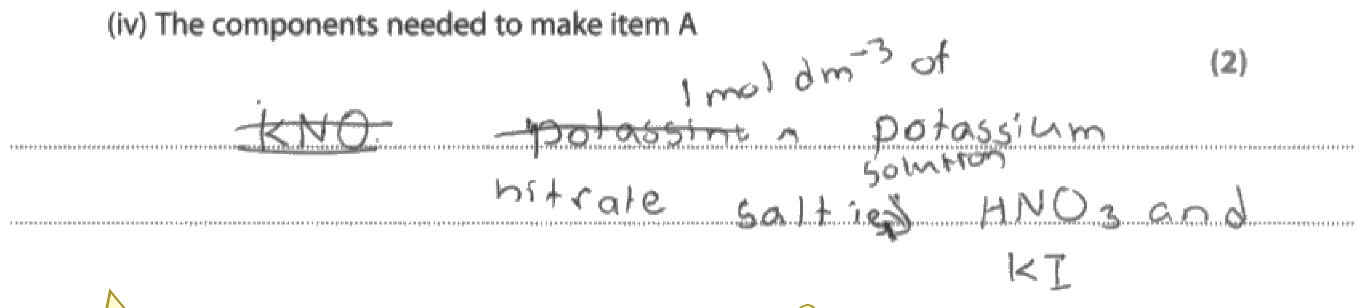
Copper was very well known.

Question 3 (a) (iii)

Candidates were fairly even split between those with a preference for platinum and iron for this electrode.

Question 3 (a) (iv)

While many candidates scored two marks for this question, the filter paper was often omitted or simply described as the 'salt bridge'. Some candidates, looking for two components, suggested ways of preparing potassium nitrate *in situ*, including those who showed little appreciation of safety and suggested the use of potassium and nitric acid.



(iv) The components needed to make item A

(2)

~~KNO~~ ~~potassium~~ ~~n~~ 1 mol dm^{-3} of potassium solution nitrate salt ie HNO_3 and KI

ResultsPlus

Examiner Comments

This response includes potassium nitrate but also a list of incorrect reagents which negate the mark.

ResultsPlus

Examiner Tip

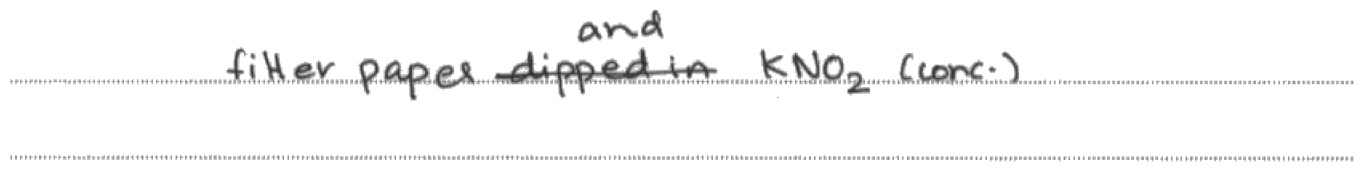
If more than one answer to a question is given, all must be correct.

platinum wire

ResultsPlus

Examiner Comments

A common incorrect response.



filter paper ~~dipped in~~ and KNO_2 (conc.)

ResultsPlus

Examiner Comments

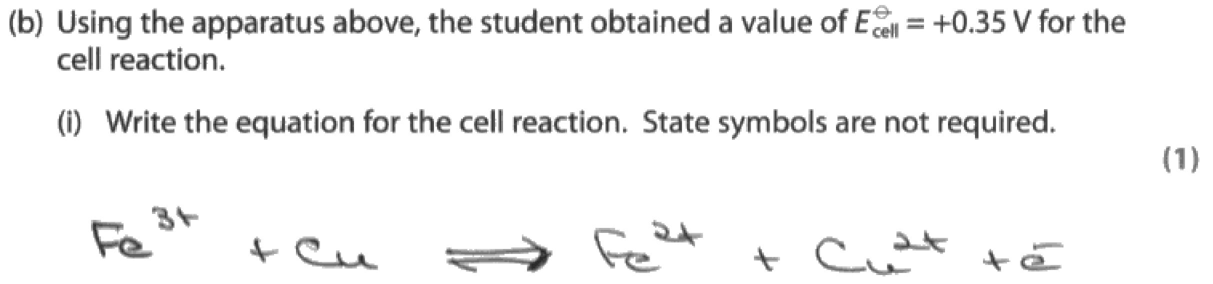
If a formula is used, with or without the name, it must be correct.

Question 3 (a) (v)

There was a very wide variety of responses to this question, the best of which fully appreciated the need for both iron(II) and iron(III) ions to be present and in concentrations of 1 mol dm^{-3}, some even explaining that mixing equal volumes would halve the original concentrations. Failure to take account of iron(III) sulfate having two moles of iron(III) ions per mole of compound lost a number of candidates a mark. Weaker responses did not include appropriate concentrations or did not realise that both iron ions were needed.

Question 3 (b)

The equation mark was frequently scored but reversing the reaction or balancing it with electrons were fairly common errors. A minority of candidates gave the cell diagram rather than the reaction equation. The majority of candidates were able to calculate E_{cell} but some then calculated the percentage accuracy (81.4%) rather than the percentage error; others used 0.35 as the denominator in their calculation.



(b) Using the apparatus above, the student obtained a value of $E^{\ominus}_{cell}$ = +0.35 V for the cell reaction.

(i) Write the equation for the cell reaction. State symbols are not required.

(1)

$Fe^{3+} + Cu \Longrightarrow Fe^{2+} + Cu^{2+} + e^-$

ResultsPlus

Examiner Comments

Only half equations can include electrons.

(b) Using the apparatus above, the student obtained a value of $E^{\ominus}_{cell}$ = +0.35 V for the cell reaction.

(i) Write the equation for the cell reaction. State symbols are not required.

(1)

$$2\,Fe^{3+} + Cu \longrightarrow 2\,Fe^{2+} + Cu^{2+}$$

(ii) Calculate the percentage error in the student's measurement compared with the value calculated using the data at the start of the question.

(2)

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

$$Fe^{3+}(aq) + e^{-} \rightleftharpoons Fe^{2+}(aq) \qquad E^{\ominus}_{Fe} = +0.77\text{ V}$$

$$E_{Cu} + E_{cell} = E_{Fe}$$

$$E_{cell} = +0.77\text{ V} - (+0.34\text{ V}) = +0.43\text{ V}$$

$$\%\ error = \frac{0.43-0.35}{0.35} \times 100\% = 22.86\ \%$$

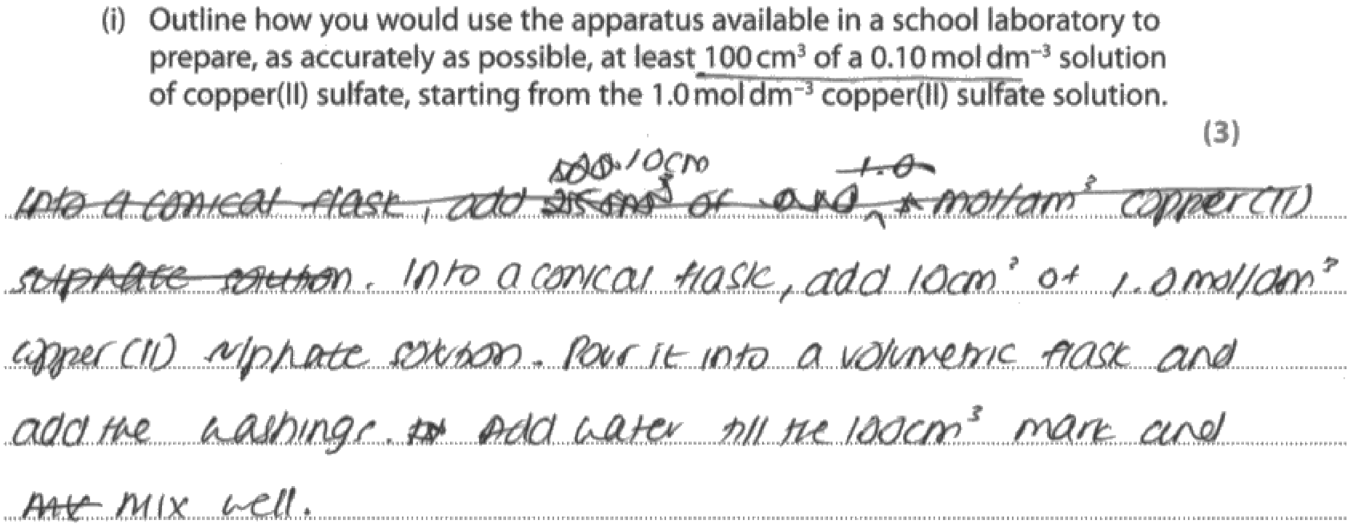
ResultsPlus

Examiner Comments

The equation and the E_{cell} calculation are correct but the error calculation uses 0.35 V as the reference point.

Question 3 (c) (i)

The quality of the responses to this question were more varied than any other. Some candidates simply did not appreciate what was required and gave detailed accounts of preparing solutions of copper(II) sulfate from the solid or even starting from copper(II) oxide. There were also extensive mole calculations aimed at determining the dilution needed but then virtually ignoring the practical aspect of the question. Where the broad thrust of the question was understood there were many examples of candidates simply mixing one part of the copper(II) sulfate solution with nine parts distilled water. Candidates who grasped the idea of the method and the need to use a volumetric flask, frequently failed to specify the use of a suitable pipette (or a burette) to measure the volume of copper(II) sulfate. Even the best responses lost marks through not mixing the diluted solution and a number of candidates described rinsing the pipette and transferring these washings to the flask.



(i) Outline how you would use the apparatus available in a school laboratory to prepare, as accurately as possible, at least 100 cm^3 of a 0.10 $mol\,dm^{-3}$ solution of copper(II) sulfate, starting from the 1.0 $mol\,dm^{-3}$ copper(II) sulfate solution.

(3)

~~Into a conical flask, add 25cm³~~ ~~100~~ 10cm³ ~~of 0.10~~ 1.0 ~~mol/dm³ copper(II) sulphate solution~~. Into a conical flask, add 10cm³ of 1.0mol/dm³ copper(II) sulphate solution. Pour it into a volumetric flask and add the washings. ~~to~~ Add water till the 100cm³ mark and ~~Add~~ mix well.

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Examiner Comments

This response scored the last two marks but not only failed to specify how the 10 cm³ of copper(II) sulfate was to be measured but transferred this solution to a conical flask first. This sort of unnecessary transfer was surprisingly common.

Using a pipette take 10 cm^3 of Copper (II) sulphate sol. of 1 mol dm^{-3} and pipette it out into a 100 cm^3 Volumetric flask. Wash the pipette into the volumetric flask with distilled water. Once this is done Contine adding distilled water into the volumetric flask tillthe marking on the flask. When it is filled upto the mark, put the cork on and shake it.

ResultsPlus

Examiner Comments

The correct method is well understood but note the rinsing of the pipette into the volumetric flask. Pipettes are calibrated not to require rinsing in this way.

Question 3 (c) (ii)

A reasonable number of candidates appreciated the effect of using the more concentrated solutions first. Most of the rest relied on stock statements about reducing percentage error or the effect of transfer losses.

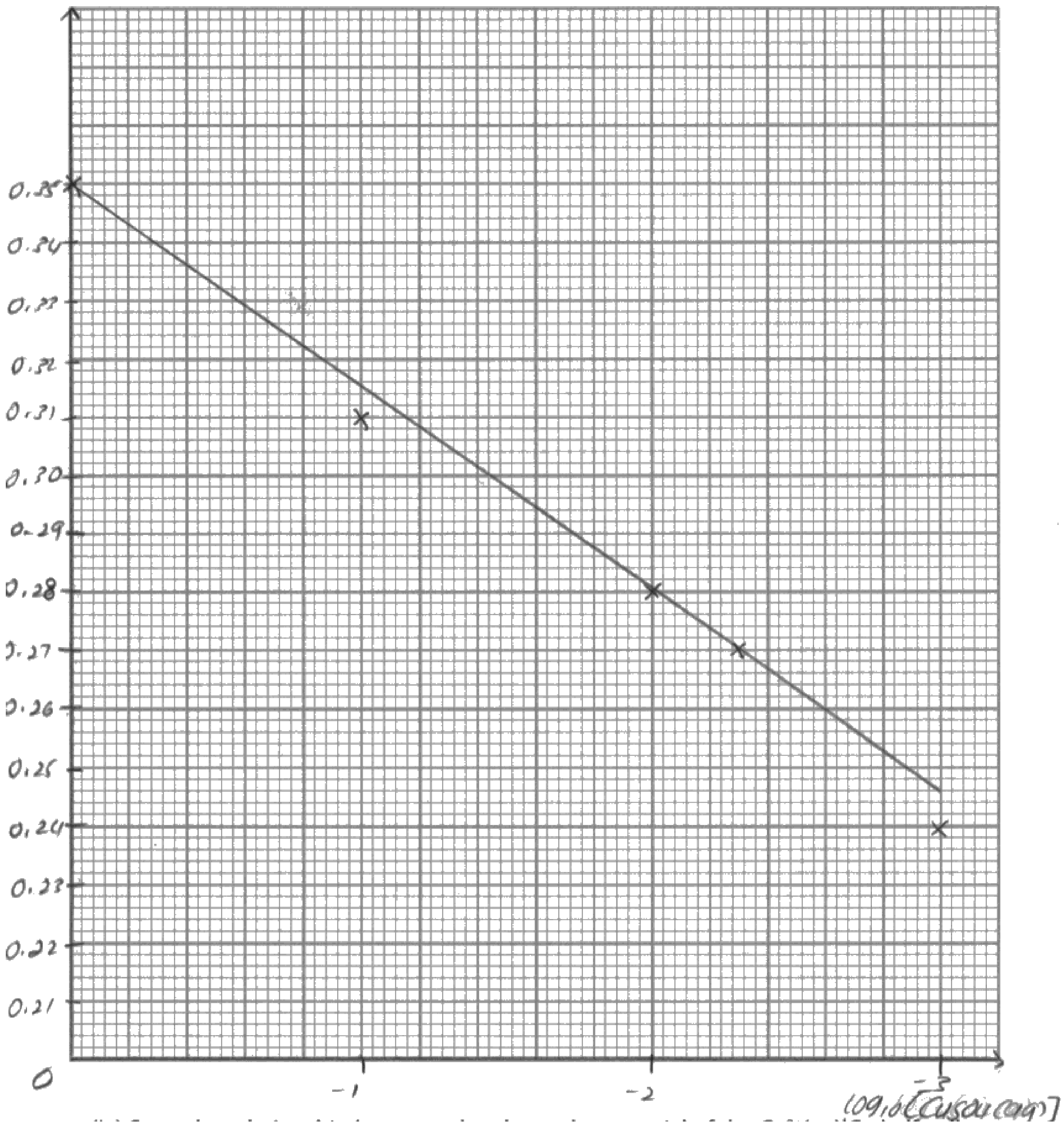
Question 3 (c) (iii)

By far the most common reason for losing a mark was attempting to start both the axes from zero, which resulted in an inappropriately small area of the graph paper being used. Some candidates reversed the scale of the log[$CuSO_4$] axis which gave rise to a negative gradient. Errors in plotting the points were most likely to occur when the scales used were poorly chosen, resulting in quite unnecessary difficulties in estimating intermediate values on the axis. On the plus side, axes were well labelled, with units when appropriate, and most candidates drew sensible best fit straight lines.

(iii) Plot a graph of electrode potential, *E*, (on the vertical axis) against $\log_{10}[Cu^{2+}]$.
Use appropriate scales, and label the axes of the graph.

Electrode potential (E)/V

(3)



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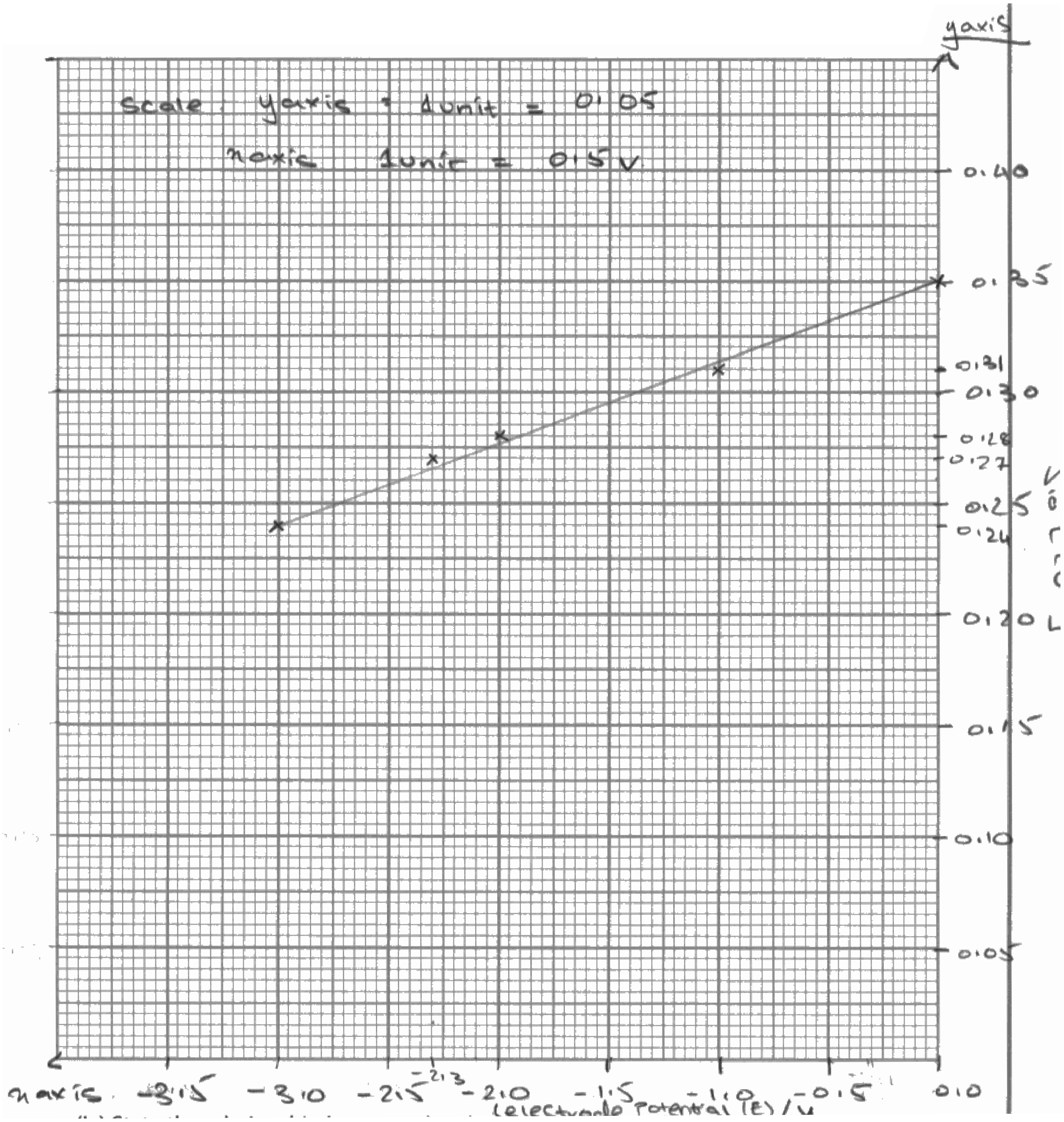
Examiner Comments

The reversal of the *x* axis scale is the only error in an otherwise well drawn graph.



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Examiner Comments

The compressed graph results from starting both axes at zero.

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Examiner Tip

When planning a graph the scales should be chosen to give the largest graph compatible with easy plotting.

Question 3 (c) (iv)

This item scored very poorly. Having just plotted a graph of electrode potential against log[$CuSO_4$], candidates almost invariably referred just to the concentration of the copper(II) sulfate.

Question 4 (a)

Only the better candidates knew the oxidising symbol.

Question 4 (b)

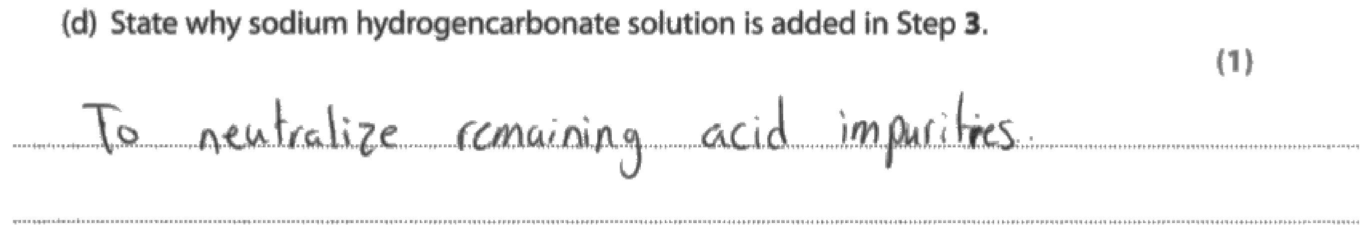
While most candidates scored this mark, there were still many who relied on vague terms such as ‘vigorous’ or on inappropriate generalisations such as quenching reactions. A significant minority wanted to discuss the evolution of heat in terms of the reaction of sulfuric acid and water.

Question 4 (c)

The possibility of further nitration was appreciated by many candidates but there were plenty of responses that referred to the possibility of evaporation or decomposition.

Question 4 (d)

The use of sodium hydrogencarbonate was familiar but otherwise there was a reliance on ideas such as quenching, borrowed from other topics, or nebulous discussions of the effect of the compound on the solubility of the desired product.



(d) State why sodium hydrogencarbonate solution is added in Step **3**.

(1)

To neutralize remaining acid impurities.

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Examiner Comments

This response scored the mark although describing the acids as impurities rather misses the point.

Question 4 (e)

The number of candidates who understand the principles involved in determining an appropriate distillation temperature range is showing a welcome improvement. However, the thinking behind many incorrect responses was hard to understand, involving very large temperature ranges and ranges that were above or below the boiling temperature.

Question 4 (f)

Most responses suggested just ‘recrystallisation’ which did not score but there were quite a few candidates who were able to work out a sensible response based on the information available to them.

Paper Summary

Based on their performance on this paper, candidates are offered the following advice:

- Read the questions carefully and check that your answers match the requirements of the questions.
- Do not give multiple responses to questions. If you offer a mixture of correct and incorrect responses, full marks may not be awarded.
- Familiarise yourself with the sequences involved in standard laboratory procedures.
- Be prepared to apply your knowledge of experimental procedures in situations that you have not come across before.
- When drawing graphs remember that the axes must be labelled with the variable and its units and the graph should use at least half the graph paper in both directions. Choose scales that make plotting intermediate values as straightforward as possible.
- Show your working in all calculations and set it out in such a way that both you and the examiner can check what you have done.

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