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Examiners' Report
June 2019

IAL Chemistry WCH13 01

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Introduction

This was the first Unit 3 paper of the 2018 IAL Chemistry Specification and, as was the case with its predecessor, it was designed to assess candidates' knowledge and understanding of the skills, procedures and techniques developed during practical work in Units 1 and 2.

As the content of the Advanced Subsidiary units is largely unchanged from the 2013 Specification, the material being examined is very similar, as is the style and layout of the questions. Any candidates familiar with the Unit 3 papers of the 2013 Specification would have been well prepared for this paper.

The only significant change for the 2018 Specification Unit 3 is the increase in the mathematical content, a change which appears to have benefited the candidates.

Candidates performed best on the questions which involved recall of chemical tests and laboratory procedures and those requiring mathematical skills. Questions which required understanding of experimental techniques and the reasons for procedures generally proved more challenging. There was no evidence of candidates having insufficient time to complete the paper.

Question 1 (a)

The common errors made when writing this equation were the omission of the balancing coefficient for the ammonia and confusion of the formulae of ammonium and ammonia.

A number of candidates gave the formula of ammonium carbonate as NH_4 CO $_3$.

Question 1 (b)

Almost all candidates knew the test for carbon dioxide and its result. The reagent for and the result of the test for ammonia were well known, but the test mark was not awarded for the addition of hydrochloric acid.

There were, however, many excellent descriptions of appropriate methods for carrying out this test. A significant number of responses gave the test for the ammonium ion while others ignored the instruction in the stem and used litmus.

Most candidates knew of a test for water, although, occasionally, there was some confusion over the observations. The test mark was not awarded for the use of a solution but the result mark was still available.

(b) Complete the table, giving a **chemical** test, not involving indicators, and its result for each of the products of the decomposition of ammonium carbonate.

(6)

Product	Chemical test	Result of test
ammonia	place an open bottle of concentrated HCl (hydrochloric acid) next to the gas (ammonia)	white smoke produced (NH_4Cl gas)
water	Add anhydrous cobalt chloride ($CoCl_2$)	colour change from ~~colourless~~ white to pink
carbon dioxide	pass (or bubble) the gas through limewater ($Ca(OH)_2$)	limewater turns milky.

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Examiner Comments

This candidate gave an excellent description of the test for ammonia with a good experimental description. The use of 'anhydrous' in the test for water is a nice detail but the start colour of the cobalt chloride is incorrect; possibly resulting from confusion between cobalt(II) chloride and copper(II) sulfate. Most candidates scored the mark for the carbon dioxide test but, once again, this candidate shows an awareness of laboratory practice by giving reference to passing the gas through lime water.

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Examiner Tip

WCH13 is a practical skills paper and the questions will aim to test awareness of good laboratory practice.

Question 1 (c)

Relatively few candidates gained the mark here.

The majority of responses ignored the instruction to use only a test tube, instead showing a variety of apparatus for collecting the gas. Where only a test tube was used, many showed an arrangement suitable for collection of a lighter-than-air gas.

Question 1 (d)

There were many good responses to these questions.

A common error in (d)(ii) was to give 'gas evolves' as an observation, rather than 'effervescence' (or one of the equivalent words).

(d) A sample of ammonium carbonate was dissolved in distilled water and the solution tested.

Complete the table to give the expected observations and the identity of the observed products.

	Test	Observation	Observed product	
(i)	About 1 cm^3 of barium chloride solution was added to 5 cm^3 of the ammonium carbonate solution	white precipitate formed	barium carbonate	(2)
(ii)	About 5 cm^3 of hydrochloric acid was added to the mixture from (i)	colourless gas given off	carbon dioxide	(2)

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Examiner Comments

The first response is concise and fully correct but 'gas evolved' is considered an inference, not an observation. The final inference mark is still scored.

Question 2 (a)

Most students were able to describe a test for a hydroxyl group.

Phosphorus(V) chloride was the preferred reagent, although a significant minority suggested sodium metal; the results of these tests were well known.

The most common incorrect reagent was acidified potassium dichromate(VI) which gained no credit.

2 A group of students was asked to investigate a liquid organic compound **A**.
They were told that it was an alcohol with molecular formula $C_4H_{10}O$.

(a) A chemical test may be used to confirm the presence of the hydroxyl group in **A**.

Identify a suitable reagent for this test, giving the positive result.

(2)

Add PCl_5 and acidified aqueous silver nitrate.
A white ppt forms

ResultsPlus Examiner Comments

Two reagents have been given but one is incorrect.

If more than one response is given to a question, all must be correct to gain the mark.

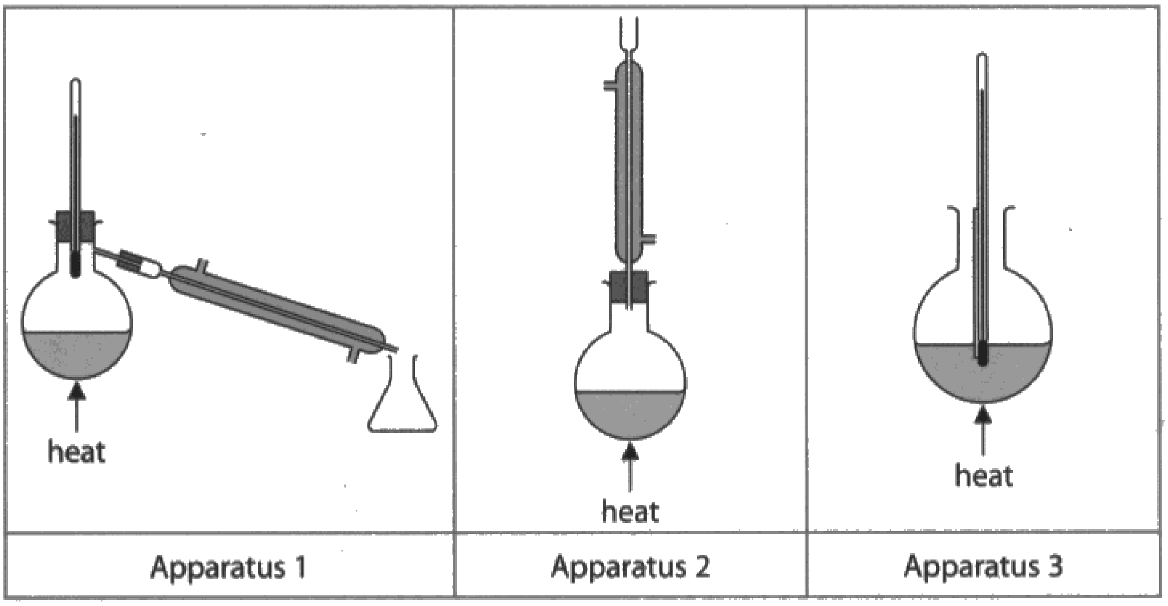
Question 2 (b) (i)

The use of acidified potassium dichromate(VI) as the oxidising agent for alcohols was very well known and the most likely error was the omission of the acid.

The oxidation state of chromium was not required but, if given, had to be correct and correctly placed, so (eg) potassium(VI) dichromate gained no credit.

Some students gave acidified potassium manganate(VII), but this also gained no credit as this is not considered a suitable reagent for this oxidation.

(b) The students suggested that oxidation of **A** would help to identify it.
The sets of apparatus shown below were provided for the students' use.



(i) Identify the reagent mixture that can be used to oxidise **A**.

(1)

potassium dichromate in sulphuric acid

$K_2Cr_2O_7$ / H_2SO_4.

ResultsPlus
Examiner Comments

The reagent names are correct, but the formula given for potassium dichromate(VI) is incorrect and this negates the mark.

Question 2 (b) (ii)

The use of distillation to isolate the aldehyde was very well known but students were less clear on the reason for this, often focusing on the practicalities of distillation rather than the importance of preventing further oxidation.

(ii) One student said that if **A** was a primary alcohol this could be shown by oxidising it to the corresponding aldehyde and testing the product.

Identify which apparatus (1, 2 or 3) should be used for this oxidation. Justify your answer.

(2)

Apparatus 1 because an aldehyde needs to be seperated from the reaction mixture, or it will undergo further oxidation to make a carboxylic acid.

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Examiner Comments

A clear and concise correct response.

Question 2 (b) (iii)

Most students were able to describe one of the standard tests for aldehydes.

The most common reason for losing the result mark was to give 'turns red' or 'red solution' rather than 'red precipitate' as the observation for the Fehling's or Benedict's tests.

Question 2 (b) (iv)

Few students appreciated that, because there are two primary alcohols with the molecular formula $C_4H_{10}O$, the aldehyde test is inconclusive.

(iv) State whether or not a positive result for the test in (b)(iii), together with the molecular formula, would allow the alcohol **A** to be identified.
Justify your answer.

(1)

The molecular formula cannot lead to conclude the existence of branch chain or not. Result in (b)(iii) only guarantees primary alcohol. So both 2-methylpropan-1-ol and butan-1-ol ~~is~~ can be the answer. A is then cannot identified.

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Examiner Comments

An impressively comprehensive response.

Question 2 (b) (v)

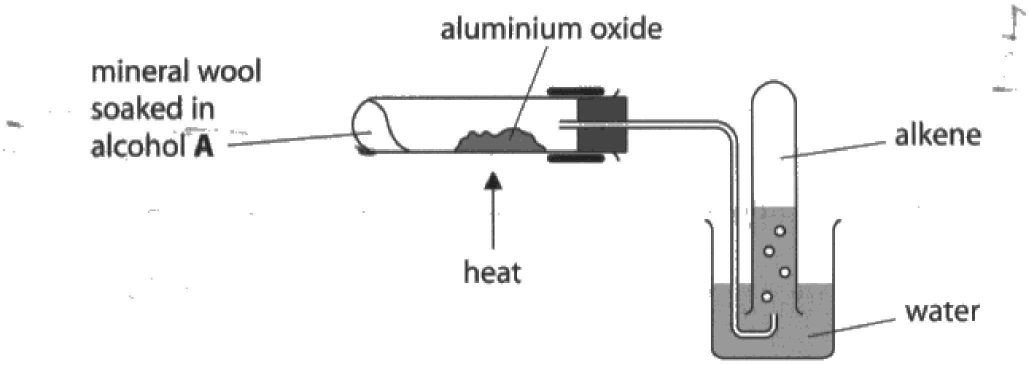
The use of reflux in the oxidation of secondary alcohols was generally well known, however, many explanations were given in terms of retaining the volatile reagents rather than ensuring complete oxidation.

Question 2 (c) (i)

Candidates were most likely to score the first and third marking points. Clear explanations of the importance of passing alcohol vapour slowly over the hot catalyst were quite rare.

(c) In a further experiment, the students passed the vapour of **A** over heated aluminium oxide to form an alkene.

The apparatus used is shown.



(i) Give **two** reasons for the use of the mineral wool.

(2)

So the alcohol stays where it's placed (liquid alcohol would move, as the test tube is tilted

The mineral wool doesn't react with the alcohol and doesn't affect the reaction

ResultsPlus
Examiner Comments

This response showed an appreciation of the practical problem of retaining a liquid reagent in a horizontal test tube and the importance of using an inert support material.

(i) Give **two** reasons for the use of the mineral wool.

(2)

→ Absorbs all of the Alcohol ~~complelel~~ completely

→ Does not react with alcohol

→ To ensure constant passing over of vapors over heated Aluminium Oxide

ResultsPlus
Examiner Comments

The first statement does not score but, as a neutral statement, does not affect the marks. The second statement is enough to gain the 'inert material' mark. The middle statement is a relatively rare appreciation of the dependence of this process on alcohol vapour passing slowly over the heated catalyst.

Question 2 (c) (ii)

There were some excellent responses with clear descriptions of suck-back and precise explanations in terms of the pressure differences, although, some students seemed unfamiliar with this type of experiment.

Some responses referred to suck-back of the alcohol or alkene which negated the mark, while others suggested that a violent reaction involving the aluminium oxide or the drop in pressure inside the reaction tube would cause an explosion to occur. Students needed to be accurate about which part of the apparatus was affected by suck-back.

(ii) **Explain why it is necessary to remove the delivery tube from the heated tube immediately when heating stops.**

(2)

As sucking back will occur. When the heating stops, the air inside the test tube cools, and the ~~pressure~~ pressure inside the test tube decreases. Hence the water will be sucked back into the test tube. When the cold water comes into ~~contact~~ ~~contact~~ contact with the hot test tube, the test tube will crack.

ResultsPlus
Examiner Comments

This response covers all the main points very clearly, showing a nice awareness of the pitfalls associated with this experiment and their underlying theory.

ResultsPlus
Examiner Tip

The careful structuring of this response is well worth studying.

Question 2 (d) (i)

The result of the bromine test for alkenes was very well known, with just a few students reversing the colours observed.

Question 2 (d) (ii)

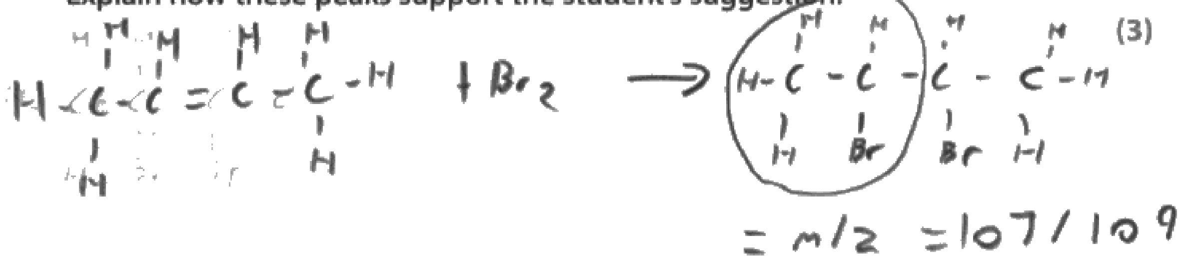
The first two marks were accessible to students who appreciated that the mass spectrum under discussion was that of a dibromobutane. The third marking point was more challenging and required more from candidates than a repetition of the phrase used in the question 'alcohol **A** must be butan-2-ol'.

The best answers to this question showed a keen understanding of the chemistry and the mass spectrometry.

(ii) The mass spectrum of $C_4H_8Br_2$ had a pair of peaks at $m/z = 107$ and $m/z = 109$ and also peaks at $m/z = 79$ and $m/z = 81$ due to the isotopes of bromine.

One student suggested that these peaks showed that alcohol **A** must be butan-2-ol.

Explain how these peaks support the student's suggestion. **(3)**



Butan-2-ol was dehydrated to form but-2-ene ~~with~~ and with the addition of ~~water~~ bromine formed 2,3 dibromobutane. This is confirmed because ~~the~~ the m/z at 107 and 109 is due to the CH3CHBr fragments which means 2,3 dibromobutane was formed. 2,3 dibromobutane must have derived from but-2-ene and only the dehydration of butan-2-ol would produce but-2-ene.

ResultsPlus
Examiner Comments

This response scored all three marks with a logically structured analysis of the data. Note the final phrase linking the but-2-ene and the butan-2-ol.

ResultsPlus
Examiner Tip

The candidate has made clever use of their structural formulae to support the response and ensure that the mass spectrometer peaks were correctly identified.

Question 3 (a) (i)

Despite the guidance given in the question, some candidates answered this question in terms of insulation, prevention of heat loss, or even the protection from burns caused by the exothermic reaction.

There were, however, many answers which showed an awareness of the practical problems involved when using a polystyrene cup.

3 A group of students carried out a thermochemistry experiment to determine the relative atomic mass of a metal, **M**.

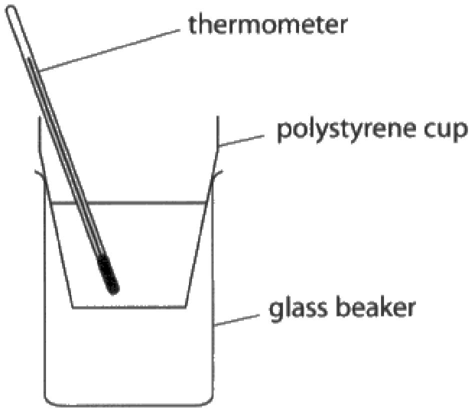
Procedure

Step **1** Transfer 50.0 cm^3 of a 1.35 mol dm^{-3} solution of copper(II) sulfate to an expanded polystyrene cup placed in a glass beaker.

Step **2** Weigh out, as accurately as possible, a known mass of the finely powdered metal **M**.

Step **3** Measure the temperature of the copper(II) sulfate solution.

Step **4** Quickly add all of the powdered metal, stir the mixture continuously and note the highest temperature reached.



(a) Each student carried out the experiment using a different mass of the metal.

(i) Give a reason, other than preventing heat loss, for placing the polystyrene cup in a glass beaker.

(1)

Glass beaker steadies the polystyrene cup and prevents it from toppling.

ResultsPlus
Examiner Comments

A typical correct response focusing on the practicalities of using a polystyrene cup, especially with a thermometer.

Question 3 (a) (ii)

Most candidates suggested using a measuring cylinder which was considered to be acceptable in view of the nature of the experiment, although not really suitable for measuring the volume to the level of precision stated in the question.

Question 3 (a) (iii)

The mark was most frequently achieved by appreciating the importance of minimising heat loss; although very few candidates understood the importance of ensuring that the heat loss should not vary with the different amounts of metal used. A significant number of responses either re-stated that the reaction of the powder would be faster, or gave explanations for the faster rate of reaction in terms of increased surface area.

(iii) Powdered metal reacts much faster than filings or granules.

Suggest why this is important in this experiment.

(1)

we need a fast rate of reaction, so less time for heat loss.

ResultsPlus
Examiner Comments

Despite its brevity, this response makes the all-important point that the duration of the experiment should be as short as possible.

It increases the surface area, thus increasing the rate of reaction.

ResultsPlus
Examiner Comments

Unfortunately, this response just re-states information given in the question.

ResultsPlus
Examiner Tip

Read all the questions carefully and try to make sure that your answer addresses the main point (or points) required.

Question 3 (b) (i) - (iii)

3(b)(i)

The quality of the graphs drawn was very high. The most common error was the omission of one or both units from the axis labels.

While candidates seemed aware of the importance of choosing scales which made good use of the available graph paper, some took this to extremes and, in trying to maximise their use of the graph paper, chose scales that were extremely difficult to plot such as using 7°C per large square. This decision was not penalised by the examiners, but it will have been time consuming to plot the points and more prone to error.

3(b)(ii)

Despite the instruction to draw two best-fit straight lines, there were many examples of point-to-point lines and curves. In contrast to the careful construction of the graph, best-fit lines were often drawn quite carelessly, with the lines not straight and, in some cases, not single lines.

3(b)(iii)

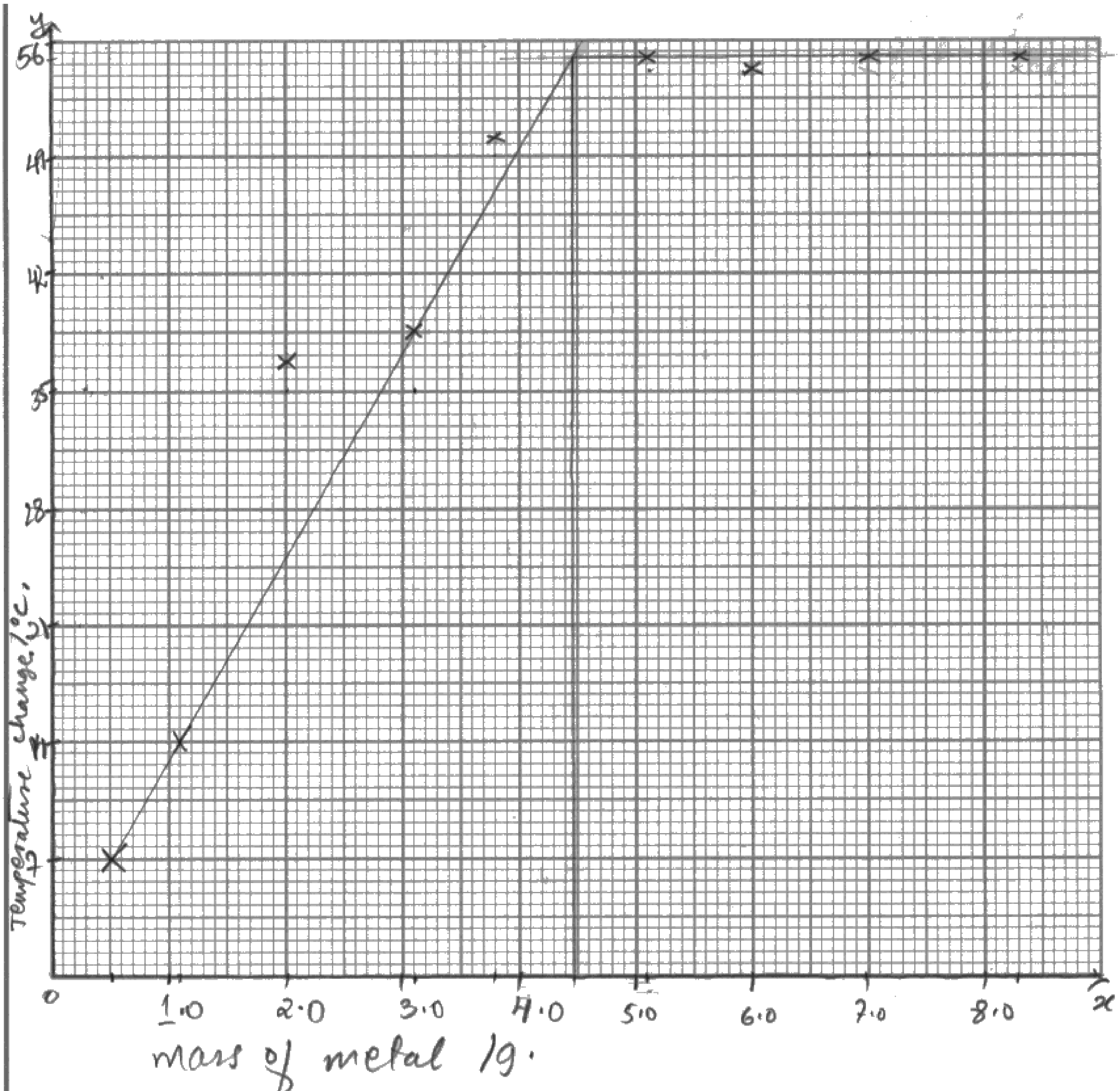
The calculation was completed successfully by many students, although some who understood the method failed to choose an appropriate number of significant figures for their final answer.

(b) The students' results were collected in a table.

Mass of metal / g	Initial temperature / °C	Final temperature / °C	Temperature change / °C
0.50	20.0	27.0	7.0
1.10	20.0	34.0	14.0
2.00	21.0	58.0	37.0
3.10	20.0	58.5	38.5
3.80	20.5	70.5	50.0
5.10	19.0	74.5	55.5
6.00	20.0	74.0	54.0
7.00	21.0	76.0	55.0
8.30	20.0	75.0	55.0

(i) Plot a labelled graph of mass of metal on the horizontal axis against temperature change on the vertical axis.

(3)



(ii) Determine the mass of metal **M** that reacts exactly with 50.0 cm^3 of 1.35 mol dm^{-3} copper(II) sulfate by drawing appropriate best-fit straight lines. You **must** show your working on the graph.

(2)

Mass of metal **M** ....4·45.... g

(iii) The equation for the reaction of **M** with copper(II) sulfate is

$$M(s) + CuSO_4(aq) \rightarrow MSO_4(aq) + Cu(s)$$

Use the equation and your answer to (b)(ii) to calculate the relative atomic mass of **M**.

Give your answer to an appropriate number of significant figures.

(3)

moles of $CuSO_4$ ⇒ $n = C \times V$

$n = 1.35 \times \frac{50.0}{1000}$

$n = 0.0675$ mol.

1 mol of M → 1 mol of $CuSO_4$

∴ moles of M ⇒ 0.0675 mol.

Mr of M ⇒ $n = \frac{M}{Mr}$

$0.0675 = \frac{4.45}{Mr}$

$4.45 = 0.0675 \times Mr$

$\frac{4.45}{0.0675} = Mr$

$Mr = 65.9$

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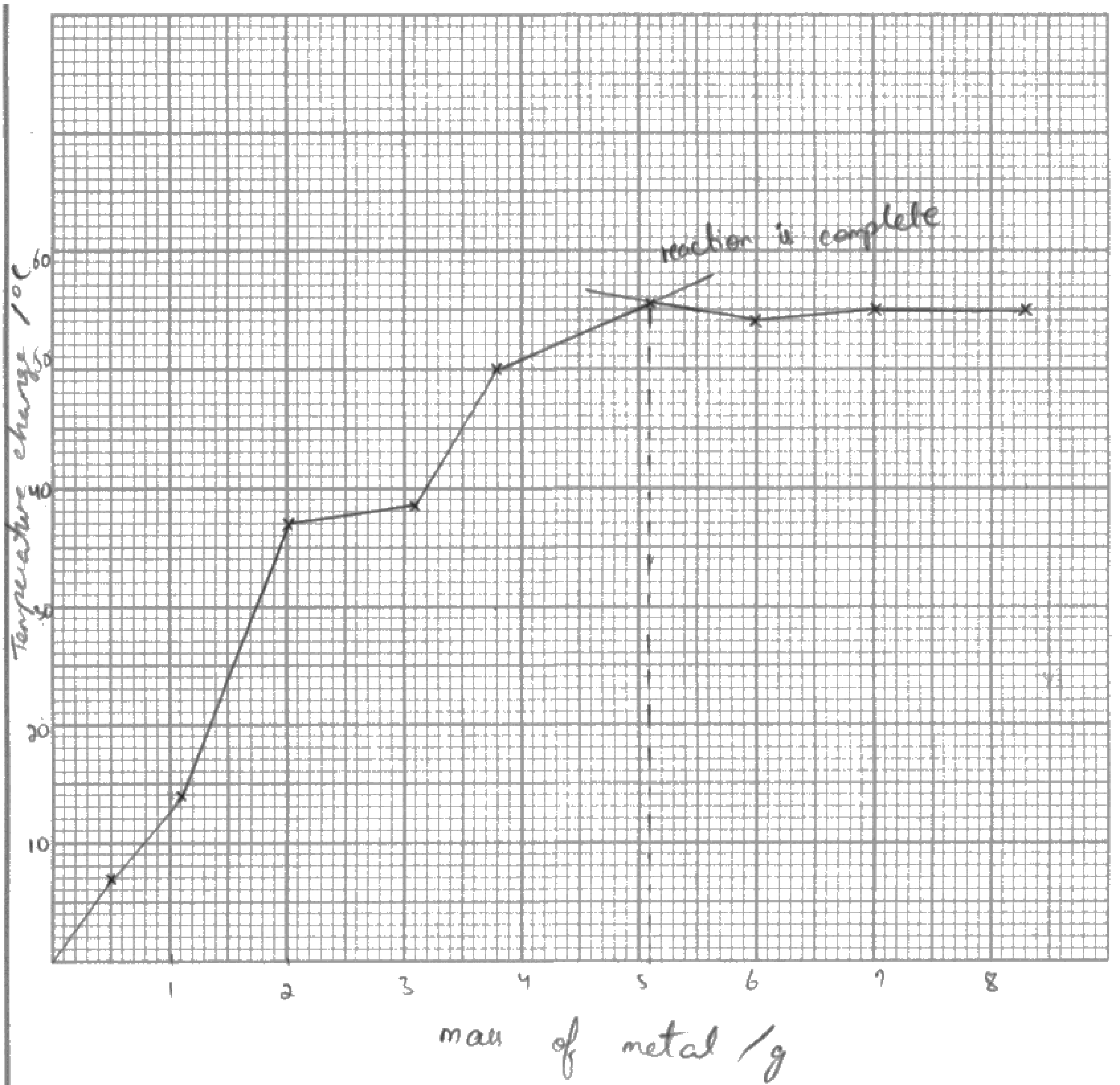
Examiner Comments

This response scored full marks in all parts of the question. The calculation is well structured and the stages clearly identified.



(ii) Determine the mass of metal **M** that reacts exactly with 50.0 cm^3 of 1.35 $mol\,dm^{-3}$ copper(II) sulfate by drawing appropriate best-fit straight lines. You **must** show your working on the graph.

(2)

Mass of metal **M** ....5.10........ g

(iii) The equation for the reaction of **M** with copper(II) sulfate is

5.10g 50.0cm³ 1.35 mol dm⁻³

$$M(s) + CuSO_4(aq) \rightarrow MSO_4(aq) + Cu(s)$$

Use the equation and your answer to (b)(ii) to calculate the relative atomic mass of **M**.

Give your answer to an appropriate number of significant figures.

(3)

moles of $CuSO_4$ = c × v
= 0.05 × 1.35
= 0.0675 moles

M	$CuSO_4$
1	1
x	0.0675

n of M = 0.0675 moles

R.A.M of M = $\frac{5.10}{0.0675}$

= 76.12

ResultsPlus Examiner Comments

The graph is well constructed and the points plotted accurately but best-fit lines have not been drawn, losing both marks for (b)(ii). The three marks for (b)(iii) were available on the transferred error principle but, although the calculation is correct, the final answer is not expressed to an appropriate number of significant figures.

Question 3 (b) (iv)

(iv) One mass of **M** in the experiment gave an anomalous data point. Suggest a reason, other than measurement error, for this anomaly.

(1)

• heat loss

• the mixture was not stirred continuosly so heat is concentrated in one area/ not evenly distributed

ResultsPlus
Examiner Comments

Sadly, this response scores zero. The excellent and well-thought-out second bullet point is contradicted by the first routine answer. It should be evident that an unexpectedly high temperature cannot be explained by heat loss.

Question 4 (a)

By far the most common error was to refer to titre values within ±0.20 cm^3, presumably confusing concordance and uncertainty.

A number of candidates defined concordant values as being 0.20 cm^3 apart rather than within a range of 0.20 cm^3. This was considered close enough to merit the mark but it is imprecise.

Many candidates appeared to consider concordance in terms of only a pair of values when it is beneficial to use a broader definition. Some candidates simply stated that concordant results were similar or in good agreement.

Question 4 (b)

Almost all candidates selected the appropriate titre values and successfully calculated the mean value.

Question 4 (c)

This question produced a wide range of responses, with either one of the correct colours or the correct pair of colours reversed gaining one mark. A common error was to give the acid to neutral colour change while a few candidates gave the colour change for phenolphthalein.

Question 4 (d)

Candidates dealt confidently with this calculation with the omission of the factor of ten being the most common error.

(d) The equation for the reaction is

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$$

Calculate the purity of the sodium hydroxide, NaOH, as a percentage by mass.

(4)

$0.095 \times \left(\frac{24.2}{1000}\right) = 0.002299$ mol

$10 \times 0.002299 = 0.02299$ in $250\ cm^3$

$0.02299 \times (23 + 16 + 1) = 0.9196g$

$\frac{0.9196}{0.95} \times 100 = 96.8\%$

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Examiner Comments

A clearly set out calculation which scored four marks.

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Examiner Tip

The significance of each line has to be inferred, which may cause problems if there is an error at some stage and the logic has to be reviewed either by the candidate or the examiner.

Thus it is best to state what is being determined at each stage of the calculation.

(d) The equation for the reaction is

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$$

Calculate the purity of the sodium hydroxide, NaOH, as a percentage by mass.

(4)

mole of HCl = 0.0950 × 0.0242

= 2.299 × 10⁻³ mol

1 mol → 40

2.299×10⁻³ ↗

40 × 2.299 ×10⁻³ = 0.09196

$\frac{0.09196}{0.95} \times 100 = 9.68$

ResultsPlus
Examiner Comments

The candidate has omitted the factor of ten but, recognising that the final answer is unlikely, has subtracted their value from 100 to provide a plausible value. This compounds the error.

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Examiner Tip

Do consider the plausibility of the value that you obtain from a calculation. If the answer seems wrong, look for an error at each stage rather than making an arbitrary change.

Paper Summary

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

- develop practical skills by completing as wide a range as possible of different experiments requiring a variety of different techniques
- understand the reasons for choosing and using particular techniques
- read each question carefully and double-check that the answer matches the requirements of the question
- endeavour to set out answers to all types of question in a logically structured format
- check that answers to numerical questions are plausible, have a sign and units where appropriate, and are given to an appropriate number of significant figures or decimal places
- remember that the Unit 3 examination paper will not be limited to recall of the core practicals, but may include questions where they are expected to apply knowledge to new experimental situations.

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