Examiners' Report
June 2025

Int Advanced Level Chemistry WCH16 01

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Introduction

Candidates performed particularly well on those questions involving calculations and/or data analysis. The questions found most challenging were those relating to the reasons behind specific steps in a practical procedure, or an understanding of the apparatus used. Candidates found it challenging to write equations to account for qualitative observations.

Question 1(a)i

This was an unfamiliar test for many candidates. Many gave the colour change of the cobalt chloride in reverse or thought this would be observed in solution rather than on the paper. Relatively few candidates understood that there would be evidence of the production of steam and there was much reference to familiar but irrelevant terms such as misty fumes.

(a) Salt **A** contains one type of cation and one type of anion.

Complete the table for the tests on a sample of the solid salt **A**.

	Test	Observations	Inference	
(i)	Heat a small amount of solid **A** in a test tube, holding some cobalt chloride paper at the mouth of the test tube.	1 steam forms mass decreases 2 the colour of paper becomes pink	**A** is a hydrated salt.	(2)

ResultsPlus
Examiner Comments

This response received 2 marks. The candidate has provided three observations so risked an incorrect observation negating a correct observation. Formation of steam and mass decreasing were both allowed, even though neither of these would actually be observed. The paper turning pink was an expected observation.

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Examiner Tip

Use any prompts provided in the question, as well as the number of marks available, to guide your response. Two observations were expected in this question.

(a) Salt **A** contains one type of cation and one type of anion.

Complete the table for the tests on a sample of the solid salt **A**.

	Test	Observations	Inference	
(i)	Heat a small amount of solid **A** in a test tube, holding some cobalt chloride paper at the mouth of the test tube.	1 pamper turns blue ~~red~~ 2 misty fumes	**A** is a hydrated salt.	(2)

ResultsPlus
Examiner Comments

This response did not receive any credit. The paper was blue at the start, and misty fumes is confused with the qualitative test for the presence of the OH group in an alcohol.

Question 1(a)ii

The most common incorrect response was Fe^{3+}, however, the **pale** brown reference should have directed candidates to manganese(II).

(ii)	Add excess aqueous sodium hydroxide to a solution of **A** and leave to stand in air.	A pale brown precipitate forms, which darkens on standing.	The **formula** of the cation in **A** is Fe^{3+}	(1)

ResultsPlus
Examiner Comments

This was a common incorrect response. Transferred error marks were still available in (a)(iv), however.

ResultsPlus
Examiner Tip

Make sure you learn the colours of the ions and compounds formed by the transition metals stated in the specification.

Question 1(a)iii

Most candidates scored well on this familiar test; however, some forget to include nitric acid or gave an unsuitable acid (eg hydrochloric acid) that would give a false result. Other candidates incorrectly chose barium chloride, showing confusion with the test for a sulfate ion.

(iii)

Add nitric acid and silver nitrate aqueous	A white precipitate forms on adding a mixture of two solutions to a solution of **A**.	The formula of the anion in **A** is Cl^-.
Add excess aqueous ammonia	The white precipitate dissolves on adding an excess of another solution.	

(2)

ResultsPlus
Examiner Comments

An excellent response scoring both marks.

(iii)

Add $Ag(NO_3)_2$ and HNO_3	A white precipitate forms on adding a mixture of two solutions to a solution of **A**.	The formula of the anion in **A** is Cl^-.
Add ~~HCl~~ $H_2SO_4(aq)$	The white precipitate dissolves on adding an excess of another solution.	

(2)

ResultsPlus
Examiner Comments

This response was awarded 0 marks. This candidate would have scored the first mark had they stated silver nitrate (and HNO_3) in words. The incorrect formula for silver nitrate negated the mark.

ResultsPlus Examiner Tip

Incorrect chemical formulae will usually be penalised.

Question 1(a)iv

Most candidates were able to deduce a correct formula for the hydrated salt, even if awarded for transferred error from an incorrect ion in (a)(ii). Some candidates failed to associate colour with a transition metal ion and received no credit for answers based on eg Mg^{2+}.

Conclusion

(iv) Give the **formula** of salt **A**, which has a molar mass of 197.9 g mol^{-1}. (2)

$MnCl_2 \cdot 4H_2O$

ResultsPlus
Examiner Comments

The correct formula of the hydrated salt was sufficient for both marks. The command was "give", which does not require any working.

Conclusion

(iv) Give the **formula** of salt **A**, which has a molar mass of 197.9 g mol^{-1}. (2)

$FeCl_4$ $\quad$ $FeOH$

$Fe(Cl_4)^{-2}$ $\quad$ 3 $\quad$ $Fe(Cl_4)^{2-}$

ResultsPlus
Examiner Comments

This response received no credit. The transferred error answer would have been $FeCl_2\ 4H_2O$ for the incorrect answer to (a)(ii).

ResultsPlus
Examiner Tip

Transferred error marks are often available so always try to complete all questions.

Question 1(b)

Many candidates struggled to produce acceptable **ionic** equations in part (i) with many unbalanced attempts, or equations involving uncancelled spectator ions seen even when a reasonable understanding of the chemistry was apparent. Similarly, many candidates did not give the formula of a **complex ion** in part (ii) or a **neutral** salt in part (iii). It was evident that many candidates found it difficult to link the observations given in the question stem to the correct chemical species.

(b) Salt **B** contains two types of cation and one type of anion.

Tests were carried out on separate samples of a solution of salt **B**.

Test **1**

Excess dilute aqueous sodium hydroxide was added and the solution warmed.
A green precipitate was observed. The precipitate turned brown on standing in air.
A piece of damp red litmus paper was held at the mouth of the test tube. The litmus paper turned blue.

$NH_4^+ + OH^- \longrightarrow NH_3 + H_2O$

Test **2**

Acidified barium chloride solution was added.
A white precipitate was observed.

(i) Write **ionic** equations to account for the following observations.
State symbols are **not** required.

(3)

Formation of **green** precipitate in Test **1**
$Fe^{2+} + 2OH^- \longrightarrow Fe(OH)_2$

Formation of gas that turned the litmus paper blue in Test **1**
$NH_4^+ + OH^- \longrightarrow NH_3 + H_2O$

Formation of white precipitate in Test **2**
$Ba^{2+} + SO_4^{2-} \longrightarrow BaSO_4$

(ii) The brown precipitate from Test **1** was dissolved in sulfuric acid.
A yellow-brown solution formed.

Give the **formula** of the **complex ion** present in the yellow-brown solution.

(1)

$[Fe(H_2O)_6]^{3+}$

(iii) State the **formula** of salt **B**.

(1)

$\cancel{FeNH_4(SO_4)_2}$ $FeNH_4(SO_4)_2$

(Total for Question 1 = 12 marks)

ResultsPlus
Examiner Comments

An excellent response to all but part (b)(iii). When deducing the formula of salt B, this candidate looks to have based their answer on Fe^{3+}, failing to appreciate this was formed by oxidation of Fe^{2+} coming from the salt.

ResultsPlus
Examiner Tip

There is little point in including state symbols if the question says they are not required.

(b) Salt **B** contains two types of cation and one type of anion.

Tests were carried out on separate samples of a solution of salt **B**.

Test **1**

Excess dilute aqueous sodium hydroxide was added and the solution warmed.
A green precipitate was observed. The precipitate turned brown on standing Fe
in air.
A piece of damp red litmus paper was held at the mouth of the test tube. The litmus paper turned blue. NH_3

Test **2**

Acidified barium chloride solution was added.
A white precipitate was observed. SO_4

(i) Write **ionic** equations to account for the following observations.
State symbols are **not** required.

(3)

Formation of **green** precipitate in Test **1**
$[Fe(H_2O)_6]^{2+} + 2OH \rightarrow [Fe(OH)_2(H_2O)_4] + 2H_2O$

0

Formation of gas that turned the litmus paper blue in Test **1**
$NH_4^+ + OH^- \rightarrow NH_3 + H_2O$

Formation of white precipitate in Test **2**
$BaCl_2 + SO_4^{2-} \rightarrow BaSO_4 + 2Cl^-$

(ii) The brown precipitate from Test **1** was dissolved in sulfuric acid.
A yellow-brown solution formed.

Give the **formula** of the **complex ion** present in the yellow-brown solution.

(1)

$[Fe(SO_4)_3(H_2O)_3]^{3-}$

(iii) State the **formula** of salt **B**.

(1)

$FeNH_4SO_4$

(Total for Question 1 = 12 marks)

ResultsPlus
Examiner Comments

This response scored 1 mark in total, for the ionic equation showing the formation of ammonia in Test 1. The ionic equation for the formation of the green precipitate would have scored had the charge been included on the hydroxide. The barium chloride in Test 2 is an aqueous solution so the barium ions must be separated from the chloride ions. The latter are spectator ions so must be omitted from the ionic equation.

ResultsPlus
Examiner Tip

Charge, as well as atoms, must balance in a chemical equation.

Question 2(a)

The most common incorrect responses related to time being needed for all the calcium hydroxide to dissolve or for the reaction to go to completion. These did not receive credit as they missed the point that equilibrium needed to be reached, where the solution was saturated and the concentration of calcium hydroxide no longer changed.

(a) Give the reason why the conical flask is left for one day at the end of Step **2**.

(1)

to make a saturated Solution

ResultsPlus
Examiner Comments

This is all that was required for the mark. The clue was in the question stem.

(a) Give the reason why the conical flask is left for one day at the end of Step **2**.

(1)

to dissolve maximum ~~all~~ ammount of the calcium hydroxide

ResultsPlus
Examiner Comments

This candidate has realised their mistake and salvaged the mark. Had all the calcium hydroxide dissolved the solution would not be saturated.

Question 2(b)

Methyl orange was the most suitable indicator for this titration between a strong acid and calcium hydroxide, which is only slightly soluble in water. Phenolphthalein, however, was a much more popular choice. Curiously, many other indicators were seen, even though the Data booklet is not provided to candidates in this examination. Many candidates incorrectly gave the colour change in reverse or gave the final colour in acid rather than at the **end-point**.

(b) Give the name of a suitable indicator to use in Step **4**, including the expected colour change at the end-point.

(2)

Name of indicator phenopthaline indicator

Colour change from pink to colorless.

ResultsPlus
Examiner Comments

This response scored both marks. Methyl orange is the expected indicator but, as calcium hydroxide can be considered a strong base, phenolphthalein is also suitable.

ResultsPlus
Examiner Tip

It is a good idea to learn the spelling of key words such as phenolphthalein.

(b) Give the name of a suitable indicator to use in Step **4**, including the expected colour change at the end-point.

(2)

Name of indicator bromophenol blue

Colour change from blue to yellow

ResultsPlus
Examiner Comments

This response scored 1 mark. As the Data booklet is not provided in WCH16, it was surprising to see a significant number of candidates give indicators other than methyl orange or phenolphthalein. This candidate is correct that bromophenol blue is blue in alkali and yellow in acid, but the colour would be green at the end-point.

Question 2(c)

Many candidates scored well on this question involving an unfamiliar titration calculation. It was disappointing, however, to see so many fail to consider the **concordant** results when calculating the mean titre in part (i), or starting with 2 g of calcium hydroxide in part (ii) or their mean titre from part (i) even though this is what they should have been trying to calculate. Many correct responses were seen in part (iii) although a significant number gave spurious reasons failing to consider the information provided in the question stem.

(c) Results from the titrations are shown.

Titration	1	2	3
Final burette reading / cm^3	9.95	19.50	28.95
Initial burette reading / cm^3	0.00	9.95	19.50
Titre of HCl(aq) / cm^3	9.95	9.55	9.45

(i) Complete the table and calculate the mean titre in cm^3.

(2)

$$\frac{9.55 + 9.45}{2} = 9.50\ cm^3$$

(ii) The equation for the titration is shown.

$$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

1.56 g dm⁻³

A data book value for the concentration of a saturated solution of calcium hydroxide at 20 °C is 1.56 g dm^{-3}.

Calculate the expected titre, using this information and that given in Step **4**.

(4)

$m = 1.56 \times 25\times10^{-3} = 0.039g$

$M_r = 40.1 + (16\times2) + (1\times2) = 74.1$

$n = \frac{0.039}{74.1} = 5.26\times10^{-4}\ mol$

$Ca(OH)_2 : HCl$

$1 : 2$

$5.26\times10^{-4} : 1.052\times10^{-3}\ mol$

$V = \frac{1.052\times10^{-3}}{0.100} = 0.01052\ dm^3 \times 10^3$

$\approx 10.52\ cm^3$

(iii) The solubility of calcium hydroxide decreases with increasing temperature.

Suggest why the mean titre from the experiment in (c)(i) does **not** agree with the expected titre from (c)(ii).

(1)

The ~~tre~~ titration was conducted at a temperature greater than 20 °C, so that the solubility of $Ca(OH)_2$ is less. Hence less aqueous $Ca(OH)_2$ forms and the titre value ~~[illegible]~~ decreases (volume of HCl required to react with $Ca(OH)_2$ decreases/lower).

ResultsPlus
Examiner Comments

An excellent response scoring full marks in each part. Note how clearly the unstructured calculation in part (c)(ii) has been presented.

ResultsPlus
Examiner Tip

Careful presentation of your working to calculations helps the examiner to apply the mark scheme.

(c) Results from the titrations are shown.

Titration	1	2	3
Final burette reading / cm^3	9.95	19.50	28.95
Initial burette reading / cm^3	0.00	9.95	19.50
Titre of HCl(aq) / cm^3	9.95	9.55	9.45

(i) Complete the table and calculate the mean titre in cm^3.

(2)

$$\frac{9.55 + 9.45}{2}$$

$$= 9.50$$

(ii) The equation for the titration is shown.

$$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

A data book value for the concentration of a saturated solution of calcium hydroxide at 20 °C is 1.56 g dm^{-3}.

Calculate the expected titre, using this information and that given in Step **4**.

(4)

$c = \frac{n}{V}$

$n = \frac{9.5}{1000} \times 0.1$

$= 9.5 \times 10^{-4}$ of HCl

$\frac{9.5 \times 10^{-4}}{2} = 4.75 \times 10^{-4}$ of $Ca(OH)_2$

$n = \frac{m}{Mr}$

$m = 4.75 \times 10^{-4} \times 74.1$

$1.56 \longrightarrow 1\ dm^3 \quad = 0.0352$

$0.0352 \longrightarrow x\ dm^3$

$x = 22.60\ cm^3$

(iii) The solubility of calcium hydroxide decreases with increasing temperature.

Suggest why the mean titre from the experiment in (c)(i) does **not** agree with the expected titre from (c)(ii).

(1)

At a lower temperature of 20°C, solubility of calcium hydroxide increases. Therefore there would be a larger concentration of $Ca(OH)_2$ in the solution in the conical flask which would require a higher titre.

ResultsPlus Examiner Comments

This response scored 2 marks in part (c)(i) and 1 mark in each of (c)(ii) and (c)(iii). This candidate has gone down the wrong path in (c)(ii), starting with a volume of hydrochloric acid and calculating a volume of calcium hydroxide solution. This incorrect approach could score a maximum of 1 mark. The candidate was given the benefit of doubt in (c)(iii) that the "lower" temperature refers to the calculation in (c)(ii) and not the titration in (c)(i). Always try to make your answers as clear as possible.

ResultsPlus Examiner Tip

Read questions carefully to make sure you are answering the question that has been asked.

Question 2(d)

In general, the candidates found it much more straightforward to evaluate the units in comparison to the numerical result of the calculation.

(d) From the results of the experiment, the student determined the concentration of the saturated solution of calcium hydroxide to be 0.0190 mol dm^{-3}.

Calculate the value of K_c, including units, from the student's result.

$$K_c = [Ca^{2+}(aq)]\,[OH^{-}(aq)]^2$$

(2)

$$K_c = [0.019][0.019 \times 2]^2$$

$$K_c = 2.74 \times 10^{-5}\ mol^3 dm^{-9}$$

ResultsPlus
Examiner Comments

An excellent response scoring both marks.

ResultsPlus
Examiner Tip

With calculations, provide your answer to the same number of significant figures as the (least accurate) data provided in the question.

(d) From the results of the experiment, the student determined the concentration of the saturated solution of calcium hydroxide to be 0.0190 mol dm^{-3}.

Calculate the value of K_c, including units, from the student's result.

$$K_c = [Ca^{2+}(aq)]\,[OH^-(aq)]^2$$

(2)

At saturation, ~~$[Ca^{2+}] = [OH$~~

$[Ca^{2+}] = [OH^-]^2$

~~$0.0190 = 0.0190^2$~~

$Kc = [Ca^{2+}(aq)]\,[OH^-(aq)]^2$

$= 0.0190 \text{ mol dm}^{-3} \times 0.0190^2 (\text{mol dm}^{-3})^2$

$= 6.859 \times 10^{-6} \text{ mol}^3 \text{dm}^{-9}$

$= 6.86 \times 10^{-6} \text{ mol}^3 \text{dm}^{-9}$

$= 6.86 \times 10^{-6} \text{ dm}^{-9} \text{mol}^3$

ResultsPlus
Examiner Comments

This response scored 1 mark. A common incorrect numerical answer where the candidate has failed to multiply the hydroxide ion concentration by two. The unit mark was awarded despite the unusual order in the final answer.

Question 3(a)

Most candidates appreciated that the thiosulfate ions react with the iodine produced but far fewer could explain that this is to delay the colour change. Confusion with iodine-thiosulfate titrations was commonplace, for example with candidates frequently saying the starch should be added after the iodine had reacted, or that thiosulfate was needed to slow the reaction or see the end-point more clearly. It was evident that many candidates did not understand the concept of a **clock** reaction.

(a) Explain why thiosulfate ions, $S_2O_3^{2-}(aq)$, are added to the reaction mixture.

(2)

The thiosulfate ions very quickly react with the iodine produced. Once all of thiosulfate ions are used up, the iodine molecules form an iodine-starch complex with starch, which causes the mixture to change from colourless to blue-black.

The thiosulfate ions thus delay the colour change.

The thiosulfate ions react with the iodine before starch can

ResultsPlus
Examiner Comments

The last two lines alone were sufficient for both marks.

Question 3(b)

This was a very poorly answered question with few candidates understanding that the concentration of the reactants was a control variable, and that this is affected by the volume of each solution added and hence the total volume. Most candidates did not go beyond a simple comparison of the accuracy of the apparatus, which was at least of some relevance. Again, much confusion with iodine-thiosulfate titrations was apparent with many candidates saying that the starch solution had to be added drop-by-drop. Some candidates thought that measuring cylinders cannot measure small volumes, even though they will have frequently used 10 ml measuring cylinders in the school laboratory.

(b) Explain why a burette, and not a measuring cylinder, is used to add the starch solution in Step **3**, even though the concentration of starch indicator does not need to be exactly the same at each temperature.

(2)

As we consider that concentration is directly proportional to volume, it is under one condition where the reaction mixture must have a constant total volume. As ~~measurin~~ burette can measure ~~more~~ less volumes more accurately, burette is used.

ResultsPlus
Examiner Comments

This candidate has not explained their answer with great clarity, however both marks were awarded. They have the right idea that the total volume needs to remain constant in order to keep the concentrations of peroxydisulfate (VI) and iodide ions the same in each experiment. Concentration is inversely, and not directly, proportional to volume but this inaccuracy was overlooked.

(b) Explain why a burette, and not a measuring cylinder, is used to add the starch solution in Step **3**, even though the concentration of starch indicator does not need to be exactly the same at each temperature.

(2)

A measuring cylinder is used when you do not need the volume to be accurate. The burette is therefore used ~~don~~ to measure an accurate volume

ResultsPlus
Examiner Comments

Because most candidates did not appreciate the significance of needing to keep the total volume the same, 1 mark was awarded to responses like this, simply for recognising that a burette is a more accurate piece of volumetric apparatus than a measuring cylinder.

Question 3(c)

Most candidates knew the colours but more confusion with iodine-thiosulfate titrations was apparent, with many giving the colour change in reverse or giving yellow instead of colourless, mistakenly thinking the starch was not already present.

(c) State the colour change in Step **5**.

(2)

Colour change from pale yellow to blue - black.

ResultsPlus
Examiner Comments

This response was awarded 1 mark for (colour changes to) blue-black. This candidate seems confused with an iodine-thiosulfate titration when the starch is added after the solution turns pale yellow. In this experiment, starch is present from the beginning and the solution turns blue-black as soon as any iodine is produced.

(c) State the colour change in Step **5**.

(2)

Colour change from blue - black to colourless

ResultsPlus
Examiner Comments

Again, this candidate seems confused with an iodine-thiosulfate titration when the solution turns colourless after all the iodine has reacted. Responses giving the reverse colour change, as here, were awarded 1 mark.

Question 3(d)i

This was a high-scoring question. When marks were not awarded this was usually due to answers being given to an inconsistent number of significant figures with the data provided in the question.

(d) Some results from the experiment are shown.

T/°C	T/K	$(1/T)/K^{-1}$	Time, t/s	$(1/t)/s^{-1}$	$\ln(1/t)$
49	322	0.00311	33	0.0303	−3.50
43	316	0.00316	47	0.0213	−3.85
36	309	0.00324	72	0.0139	−4.28
31	304	0.00329	99	0.0101	−4.60
25	298	0.00336	147	0.00680	−4.99

(i) Complete the table.

(3)

ResultsPlus
Examiner Comments

This candidate has successfully calculated all values and completed the table consistently with the precision of the data shown. Full marks were awarded.

(d) Some results from the experiment are shown.

T/°C	T/K	$(1/T)$/K^{-1}	Time, t/s	$(1/t)$/s^{-1}	ln$(1/t)$
49	322	0.00311	33	0.0303	−3.50
43	316	0.00316	47	0.0213	−3.85
36	309	0.00324	72	0.0139	−4.28
31	304	0.00329	99.5	0.01005	−4.60
25	298	0.00336	147	0.00680	−5.

(i) Complete the table.

(3)

ResultsPlus
Examiner Comments

This candidate has correctly calculated all values but has given the Time, t, the (1/t), and the ln(1/t) values to an inconsistent number of significant figures in relation to the data provided. This error was penalised only once and 2 marks were awarded.

ResultsPlus
Examiner Tip

Always be consistent with the precision of the data provided.

Question 3(d)ii

Many candidates gave a correct answer, however, much carelessness with units was observed. Other candidates unsuccessfully attempted to use the expression provided, instead of simply multiplying the gradient value by the gas constant.

(ii) The experimental data was plotted on a graph of $\ln(1/t)$ against $1/T$, giving a straight line with gradient, $m = -6045$ K.

Calculate the activation energy, E_a, for this reaction, in kJ mol^{-1}, using this result.

$$\ln(1/t) = -\frac{E_a}{R} \times \frac{1}{T} + \text{constant} \qquad R = 8.31\ \text{J mol}^{-1}\text{K}^{-1}$$

(1)

$$m = -\frac{E_a}{R} = -6045$$

$$\Rightarrow E_a = -(-6045) \cdot 8.31 = 5.02 \times 10^4\ \text{J mol}^{-1}$$

$$= 50.2\ \text{kJ mol}^{-1}$$

ResultsPlus
Examiner Comments

An excellent response. This candidate has shown their working and clearly given thought to the sign of their answer, the number of significant figures, and the units.

ResultsPlus
Examiner Tip

"SUS" is a useful acronym to remember in calculations: Sign, Units, Significant figures.

(ii) The experimental data was plotted on a graph of ln (1 / *t*) against 1 / *T*, giving a straight line with gradient, $m = -6045\,K$.

Calculate the activation energy, E_a, for this reaction, in $kJ\,mol^{-1}$, using this result.

$$\ln(1/t) = -\frac{E_a}{R} \times \frac{1}{T} + \text{constant} \qquad R = 8.31\,J\,mol^{-1}\,K^{-1}$$

(1)

$-3.5-(-3.85) = 0.35$

$0.00311 - 0.00316 = -5\times10^{-5}$

$-\frac{Ea}{R} = \frac{0.35}{-5\times10^{-5}}$

$-\frac{Ea}{8.31} = -7000$

$Ea = 58170\,J\,mol^{-1} = 58.17\,kJ\,mol^{-1}$

ResultsPlus Examiner Comments

This candidate understands how to calculate activation energy from an Arrhenius plot but did not score the mark despite doing a lot of work. They have ignored the instructions and calculated their answer using data from the table rather than the more straightforward use of the gradient value provided in the question.

ResultsPlus Examiner Tip

Always read questions and follow instructions carefully: do not write your own question.

Question 4(a)

The majority of candidates correctly stated the use of gloves; however, many did not read the question carefully and gave multiple precautions.

(a) State the main safety precaution, other than wearing safety spectacles and a laboratory coat, that should be taken when weighing the phenol in Step **1**.

(1)

Wearing gloves

ResultsPlus
Examiner Comments

A concise response that scored the mark. The command was "state" so no reason or explanation was required.

Question 4(b)

A lack of specificity meant that a significant number of candidates did not score the mark, for example by simply referring to the production of toxic gases. Other candidates made up hazards, such as benzoyl chloride being carcinogenic, even though the relevant information was provided in the table on the preceding page. As with the previous question, numerous candidates gave several reasons instead of just **one** as instructed.

(b) Give **one** reason why Step **2** must be performed in a fume cupboard.

(1)

toxic gas must be evolved and they are corrosive and toxic by inhalation ∴ done in fume cupboard.

ResultsPlus
Examiner Comments

Reference to the production of a toxic gas alone was not sufficient for the mark. Several substances are involved in the preparation, not all of which are toxic.

ResultsPlus
Examiner Tip

Hazards are specific to chemicals.

(b) Give **one** reason why Step **2** must be performed in a fume cupboard.

(1)

Benzoyl-Chloride is toxic by inhalation

ResultsPlus
Examiner Comments

A concise response that scored the mark. Benzoyl chloride and hydrogen chloride were the two toxic chemicals involved in the preparation.

Question 4(c)

This question was answered very well. Some candidates did not make a comparison, which was necessary to show why the volume of benzoyl chloride did not need to be exact, and so were not awarded full marks.

(c) Deduce why the volume of benzoyl chloride added in Step **2** does **not** need to be exact.
Include a calculation in your answer.

[Density of benzoyl chloride = 1.21 g cm^{-3}]

(4)

$n_{phenol} = \frac{5}{12\times6+5+16+1} = 0.0532$ mol

~~Benzoyl Cer~~ $n_{C_6H_5COCl}$ needed = 0.0532 mol

$n_{C_6H_5COCl}$ added = $\frac{1.21 \times 9}{140.5}$ = 0.0775 mol

$\therefore n_{C_6H_5COCl}$ added > $n_{C_6H_5COCl}$ required.

Benzoyl chloride is in excess. So the volume does not need to be exact.

ResultsPlus
Examiner Comments

A concise and clearly presented response scoring full marks.

(c) Deduce why the volume of benzoyl chloride added in Step **2** does **not** need to be exact.
Include a calculation in your answer.

[Density of benzoyl chloride = 1.21 g cm^{-3}]

(4)

density = $\frac{\text{mass}}{\text{volume}}$

Volume = $\frac{\text{mass}}{\text{density}} = \frac{7.4734}{1.21}$

= 6.17 cm^3

number of moles of C_6H_5OH = $\frac{5}{94}$ = 0.05319

number of moles in benzoylchloride = same

$n = \frac{m}{Mr}$

mass of benzoyl chloride = $m = n \times Mr$
= 0.05319 × 140.5
= 7.473404

because the melting temprature is too low it's not going to get affected by that so no matter what volume being used the benzyl chloride won't discolve in the mixture be cause it's immersible.

ResultsPlus
Examiner Comments

This candidate has not presented their work in the most logical order; however, they have correctly calculated the volume of benzoyl chloride required and were awarded 3 marks. Note that their answer should have been rounded to 6.18 cm^3 but this was ignored on this occasion as the precision was of little significance in the context of the question.

ResultsPlus
Examiner Tip

Incorrect rounding will almost always be penalised in calculation questions. It is best practice to carry through calculator values in intermediate steps before making sure your final answer is correctly rounded and given to an appropriate number of significant figures.

Question 4(d)

Most candidates approached this question too generally and did not appear to give any thought to the specific chemicals involved. The removal of excess benzoyl chloride, following on from the previous question, was a key idea that was missed by the large majority of candidates. Many vague responses of just removing impurities, or worse insoluble impurities, were seen.

(d) Give **two** reasons why the crude product is washed with **water** in Step **3**.

(2)

, To remove excess benzoyl chloride

> ~~To water a~~ phenyl benzoate is insoluble in water

so no product is dissolved ~~&~~ and lost.

ResultsPlus
Examiner Comments

A good response scoring both marks. Only a small proportion of candidates recognised that water would help to remove any unreacted benzoyl chloride. Reference to phenyl benzoate having a low solubility in water was allowed in the second marking point.

(d) Give **two** reasons why the crude product is washed with **water** in Step **3**.

(2)

To remore soluble impurities and

to remore sodium hydroxide

ResultsPlus
Examiner Comments

This response scored 1 mark. Sodium hydroxide is one of the soluble impurities removed by water. It is always best to be specific when giving reasons for steps in practical procedures.

Question 4(e)i

This was a very poorly answered question with most candidates discussing the dissolving of the crystals, the removal of impurities or the evaporation of ethanol. Only a tiny proportion of candidates considered the melting temperature data provided in the table and understood its significance. Recrystallisation must be done from the solid.

(i) The boiling temperature of ethanol is 78 °C.

Suggest why the crystals are dissolved in ethanol at 60 °C, even though this is lower than the boiling temperature of ethanol.

(1)

~~To prevent formation of crystals ethanol from evaporateg~~, to prevent melting of phenyl Benzoate ~~wh~~ as it's melting point is 71°C

ResultsPlus
Examiner Comments

A good response to a challenging question. This candidate initially went down the wrong path but realised their mistake, presumably after considering the data provided in the preceding table.

ResultsPlus
Examiner Tip

Any work that you do not want to be marked should be neatly crossed out with a single line, as here.

(e) The recrystallisation in Step **4** was carried out using this method:

- transfer the crude product to a boiling tube and cover in ethanol
- place the boiling tube in a water bath at 60 °C
- add ethanol until the solid completely dissolves after stirring
- cool the solution in an ice-water bath until crystals appear
- filter the crystals by suction filtration
- wash the crystals with **cold** ethanol.

(i) The boiling temperature of ethanol is 78 °C.

Suggest why the crystals are dissolved in ethanol at 60 °C, even though this is lower than the boiling temperature of ethanol.

(1)

- ethanol is needed to dissolve the solid, if the crystal was heated at above 60°C and near the Boiling temperature of ethanol then ethanol would be vaporized

ResultsPlus
Examiner Comments

A common incorrect response. This candidate has failed to consider the relevance of the melting temperature of phenyl benzoate provided in the preceding table.

ResultsPlus
Examiner Tip

When a table of data relating to the compounds involved in an organic preparation is provided, it is expected that this will be considered when answering the questions that follow.

Question 4(e)ii

This question was well-answered overall with many candidates knowing this was to remove soluble impurities while preventing the crystals from redissolving. As with (d), some candidates confused soluble with insoluble impurities.

(ii) Explain why the crystals are **washed** with **cold** ethanol.

(2)

Crystals are less soluble in cold ethanol
This washing is for removing soluble
impurities

ResultsPlus
Examiner Comments

A concise response scoring both marks.

(ii) Explain why the crystals are **washed** with **cold** ethanol.

(2)

Ethanol is volatile & if it's used while it's hot, it will
easily evaporate and probably react with the crystals even
when washing. Cold ethanol is better for washing
of the crystals as it efficiently remove impurities
while it's cold than hot.

ResultsPlus
Examiner Comments

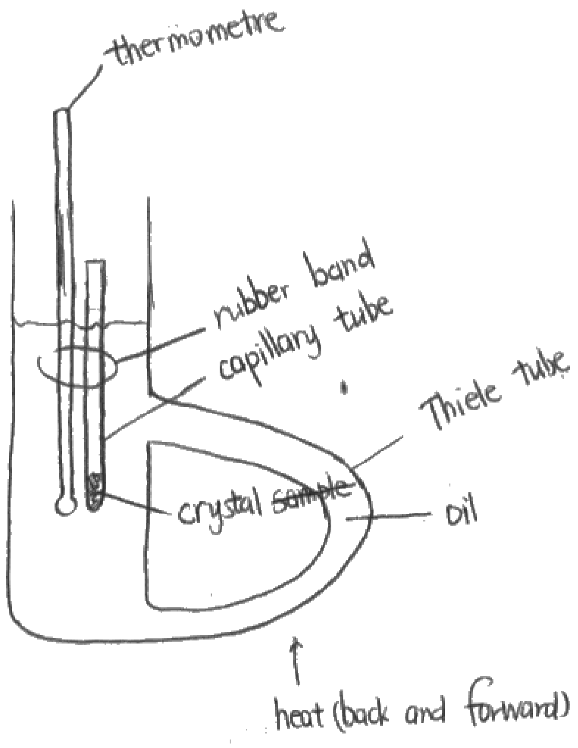
This response did not receive any credit. The purpose of washing is always to remove soluble impurities. Hot ethanol would dissolve the crystals; "react with" is an inaccurate term.

Question 4(f)

The overall standard of diagrams of this unfamiliar apparatus was, encouragingly, better than expected. A significant number of responses included apparatus that would not work, for example with thermometer bulbs not in contact with the liquid in the Thiele tube (or, worse, placed inside the capillary tube) or the capillary tube containing the crystals being completely immersed in the liquid. Other responses included unsuitable methods of heating, eg failing to read the instructions and giving an electrical heater.

(f) Draw a **labelled** diagram of the apparatus that could be used to measure the melting temperature of phenyl benzoate in Step **5**.
You should assume that electrical equipment for measuring the melting temperature is **not** available.

(3)

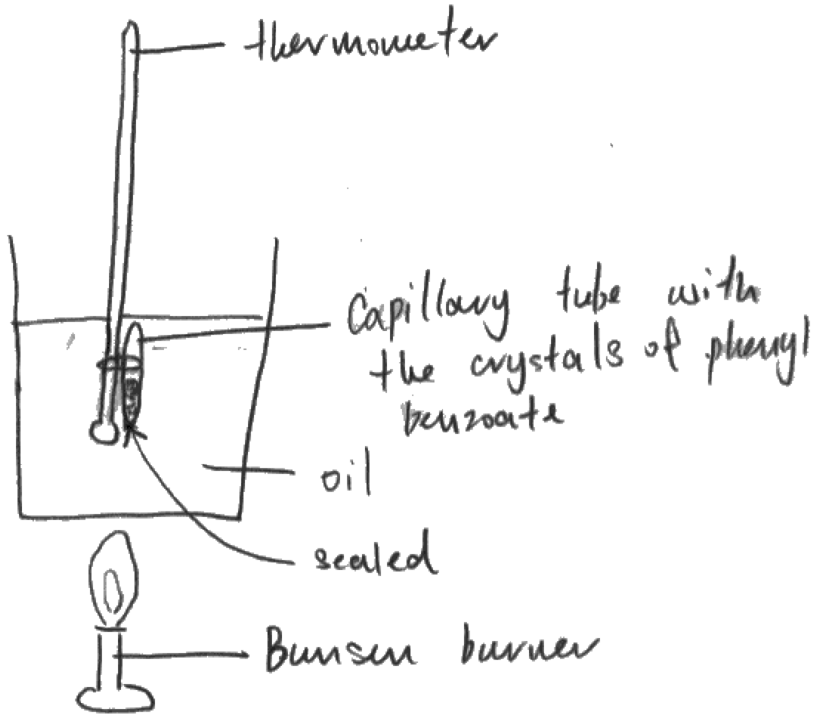


ResultsPlus
Examiner Comments

A good response with a clearly labelled diagram scoring all three marks.

(f) Draw a **labelled** diagram of the apparatus that could be used to measure the melting temperature of phenyl benzoate in Step **5**.
You should assume that electrical equipment for measuring the melting temperature is **not** available.

(3)



ResultsPlus
Examiner Comments

This response scored 2 marks. Full marks would have been awarded had the capillary tube not been completely immersed in the oil.

Question 4(g)

This straightforward percentage yield calculation was done very well by the majority of candidates.

(g) Calculate the mass of phenyl benzoate that can be prepared from 5.00 g of phenol if the overall yield, by mass, is 65.0%.

(2)

$n\ C_6H_5OH: 5 \div 94 = 0.05319$ mol.

$n\ C_6H_5COOC_6H_5 = 0.05319 \times 65\% = 0.03457$ mol.

$m\ C_6H_5COOC_6H_5 = 0.03457 \times 198 = 6.8457$ g

≈ 6.85 g.

ResultsPlus
Examiner Comments

A clearly presented calculation scoring both marks. The candidate has worked to a suitable number of significant figures in the intermediate steps before correctly rounding their final answer.

(g) Calculate the mass of phenyl benzoate that can be prepared from 5.00 g of phenol if the overall yield, by mass, is 65.0%.

(2)

Mr = 198.0 → phenyl benzoate
Mr = 94 → phenol

mol = $\frac{5}{94}$ = 0.0532 mol   1:1

×65%
= 0.03458 mol

mass = mol × mr = 0.03458 × 198.0
= 6.84 g

ResultsPlus
Examiner Comments

This was awarded 1 mark as the final answer is incorrectly rounded. A careless mistake in an otherwise well-crafted response.

Paper Summary

Based on their performance on this paper, candidates should:

- Make sure they consider the context of each question and avoid giving generic responses.
- Practise writing equations to account for the results of qualitative tests mentioned in the specification.
- Learn the colour and formulae of transition metal ions and compounds mentioned in the specification.
- Think more carefully about the reasons behind each step in a practical procedure.
- Understand the suitability of apparatus to its use in a practical procedure.
- Make better use of data provided in the context of an organic preparation.

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