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June 2014

IAL Chemistry WCH03 01

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June 2014

Publications Code IA038351

Introduction

This paper was accessible to all candidates and very few questions were not attempted.

There were many good answers to the questions on inorganic observations and the thermometric titration. The questions on organic chemistry and procedures in preparing an organic liquid were less well answered. It was evident that many candidates were not sure how the information in mass spectra and infrared spectra could be used. It was also evident that many candidates did not take enough care in reading the procedure for preparing butanone in the final question, and so did not realise why certain steps were carried out in a particular way.

The calculations using titration results were well done, but the calculation in the final question was often very difficult for examiners to follow. Candidates should be encouraged to state what they are calculating at each stage.

Question 1 (a)

There are many different words to describe the flame colour produced by calcium. The traditional term "brick red" was often given, but other descriptions indicating the red tinge in the flame were allowed. A yellow flame is produced by sodium ions and a crimson flame by strontium ions so these were not allowed.

	Test	Observation	Inference
(a)	Carry out a flame test on **A**.	crimson (brick-red)	Cation is calcium.

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Examiner Comments

The strontium flame is described as crimson and this colour is not the same as brick red. Therefore no marks were given here.

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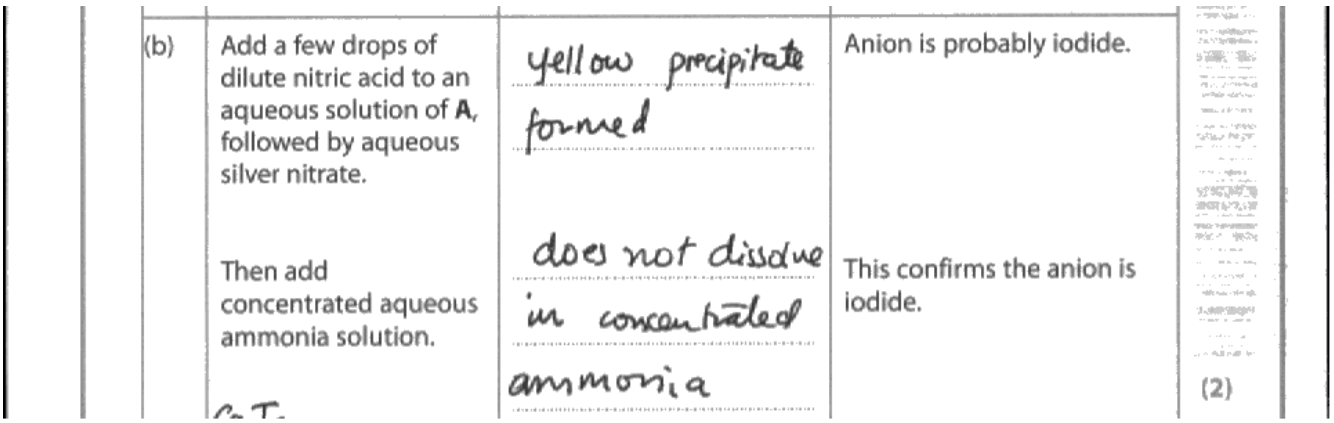
Examiner Tip

Don't give two alternative answers to a question as if one is wrong you will not get a mark for the correct one.

Question 1 (b)

This was often answered correctly, though a few candidates said the mixture was yellow and did not score unless they also said that a precipitate or solid formed. This precipitate is insoluble in ammonia, and answers such as "nothing happens" (when ammonia is added) were only allowed if the first part had made it clear that a solid was present.



(b)	Add a few drops of dilute nitric acid to an aqueous solution of **A**, followed by aqueous silver nitrate.	yellow precipitate formed	Anion is probably iodide.	
	Then add concentrated aqueous ammonia solution.	does not dissolve in concentrated ammonia	This confirms the anion is iodide.	(2)

ResultsPlus
Examiner Comments

This is an example which scored both marks.

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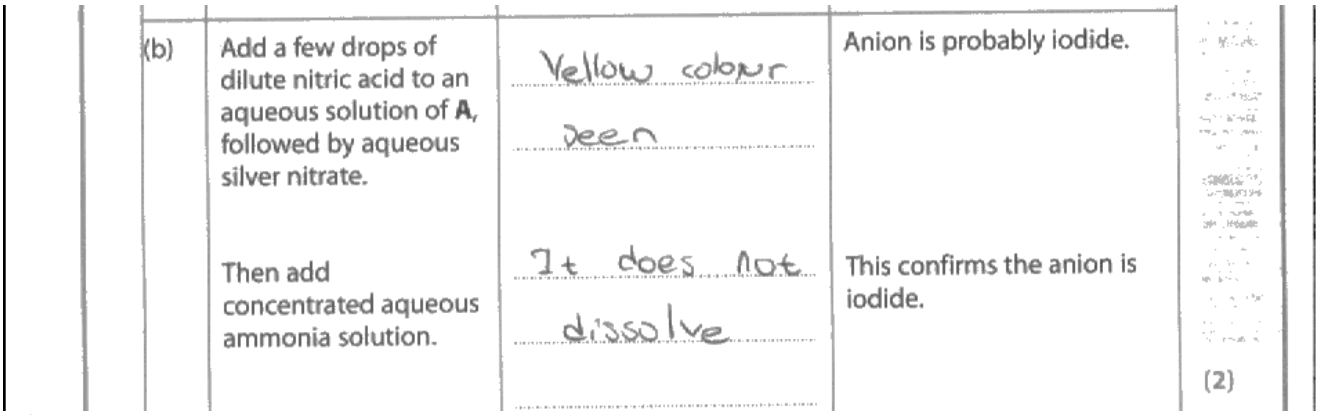
Examiner Tip

Learn the colours of the precipitates formed when silver nitrate reacts with solutions containing halide ions, and the solubility of silver halides in ammonia. These tests are often used to identify the halide.



(b)	Add a few drops of dilute nitric acid to an aqueous solution of **A**, followed by aqueous silver nitrate.	Yellow colour seen	Anion is probably iodide.	
	Then add concentrated aqueous ammonia solution.	It does not dissolve	This confirms the anion is iodide.	(2)

ResultsPlus
Examiner Comments

There is no mark for saying that a yellow colour is seen. The formation of a precipitate had to be included.

ResultsPlus
Examiner Tip

As no precipitate was mentioned, there was no mark for saying "It" does not dissolve.

Be careful with the use of the word "it". You must be clear about what you are referring to when you use "it".

Question 1 (c)

This question asked for the colour of the solution produced when chorine reacts with iodide ions displacing iodine. A description of solid iodine did not answer the question. However, many different answers were accepted, as the colour of the solution would depend on the iodine concentration.

(c) Add an aqueous solution of chlorine to an aqueous solution of **A**.	The colour of the resulting solution is ~~yellow~~ brown	The colour is due to the formation of I_2 (iodine)	(2)

ResultsPlus
Examiner Comments

It is true that the colour of the solution gets darker when iodine is displaced, but the question asked for a colour so this did not get the mark.

ResultsPlus
Examiner Tip

Always read the question carefully. The observation required you to give the colour of the mixture when chlorine reacted with iodide ions and just saying "darker" is not a specific colour.

Question 1 (d)

Candidates who had deduced that the mixture being tested contained iodine often got this right. However, the various colours of iodine in different conditions were often mixed up.

(d) Add an aqueous solution of starch to the mixture formed in (c).	The colour of the resulting mixture is purple.	This confirms the inference made in (c).	(1)

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Examiner Comments

Some candidates knew the various colours of iodine in different conditions but could not match the correct colour to the situation.

ResultsPlus
Examiner Tip

You need to learn the colour of iodine when it is solid, gaseous, in aqueous solution, in an organic solvent and when it reacts with starch.

Question 01 (e)

This question was often answered correctly. However, many incorrect suggestions for the identity of the precipitate and gas were seen. Some of these contained elements that were not present in the reaction. The compounds in the question were sodium carbonate and calcium iodide, and answers such as sodium chloride precipitates or sulfur dioxide gas suggested a lack of any thought.

(e)	Add a solution of sodium carbonate to an aqueous solution of **A**.	A white precipitate forms.	The precipitate is Ca^{+2}
	When there is no further change, add dilute hydrochloric acid to the mixture.	The precipitate dissolves in the acid and bubbles of gas are seen.	The gas is hydrogen

(2)

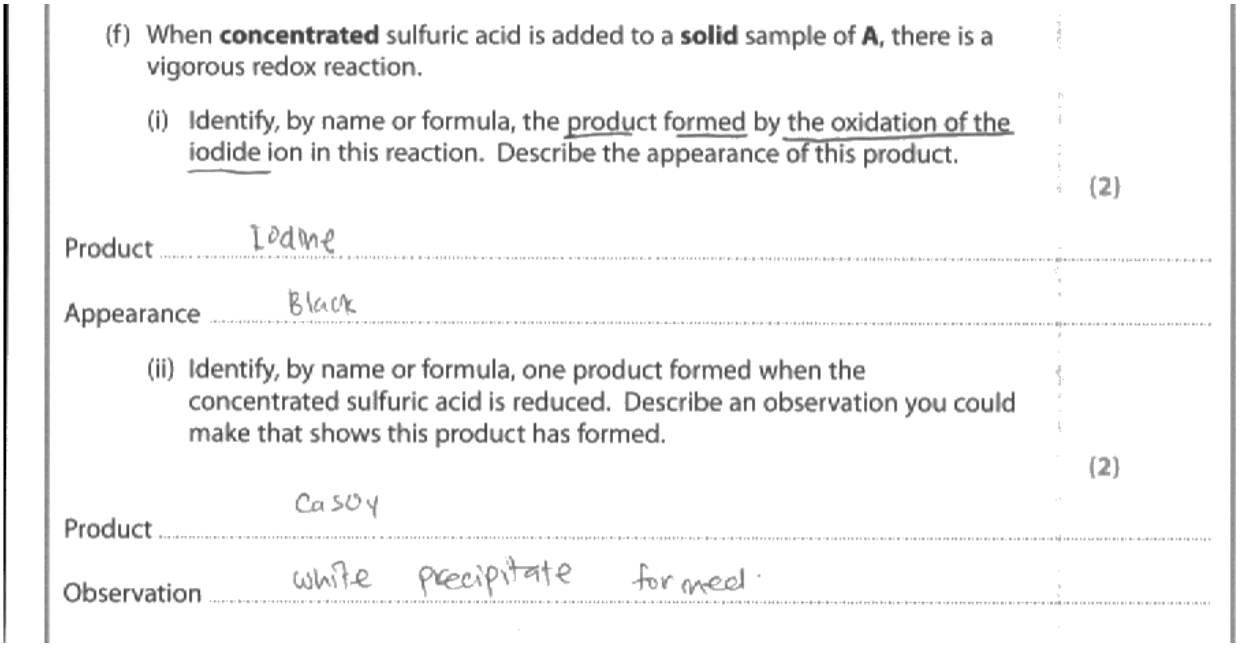
ResultsPlus
Examiner Comments

The precipitate does contain calcium ions but the full identification of the compound is needed.

Question 1 (f)

The oxidation of iodide ions produces iodine; the appearance of iodine depends on its state, so it had to be clear whether a solid or gas was being described.

There were several possible answers for the product of reduction of sulfuric acid. The observation which was described had to match the product named, so there were no marks for describing the smell of rotten eggs if the product was stated to be sulfur dioxide.



(f) When **concentrated** sulfuric acid is added to a **solid** sample of **A**, there is a vigorous redox reaction.

(i) Identify, by name or formula, the product formed by the oxidation of the iodide ion in this reaction. Describe the appearance of this product. **(2)**

Product: Iodine

Appearance: Black

(ii) Identify, by name or formula, one product formed when the concentrated sulfuric acid is reduced. Describe an observation you could make that shows this product has formed. **(2)**

Product: CaSO4

Observation: white precipitate formed

ResultsPlus
Examiner Comments

The iodide ion would be oxidized to iodine, and again the appearance would depend on whether the iodine was solid, a vapour or in solution. This answer should have referred to the solid forming for "black" to be accepted as the appearance.

Concentrated sulfuric acid would be reduced to a product in which the oxidation number of sulfur is less than +6 and sulfur dioxide, sulfur and hydrogen sulfide were all allowed.

ResultsPlus
Examiner Tip

You can work out if a reduction is occurring by looking at whether there is a drop in oxidation number. Calcium sulfate and sulfuric acid both contain sulfate ions, so formation of calcium sulfate would not be a reduction.

(f) When **concentrated** sulfuric acid is added to a **solid** sample of **A**, there is a vigorous redox reaction.

(i) Identify, by name or formula, the product formed by the oxidation of the iodide ion in this reaction. Describe the appearance of this product.

(2)

Product Iodine

Appearance Black solid

(ii) Identify, by name or formula, one product formed when the concentrated sulfuric acid is reduced. Describe an observation you could make that shows this product has formed.

(2)

Product Sulfur dioxide gas

Observation Effervescence

ResultsPlus
Examiner Comments

This candidate got the marks for describing the solid iodine, but effervescence shows that gas bubbles are forming and does not specifically indicate the presence of sulfur dioxide.

ResultsPlus
Examiner Tip

When you give an observation showing that sulfur dioxide forms, it should be more specific than this one.

Question 2 (a) (b)

The first part of the question was not often answered correctly. Many candidates thought of the mass spectrum of an element with several isotopes, and described the process of taking the weighted mean of the mass of each isotope. The candidates who realised that the mass spectrum of a compound showed the masses of the fragments present often said that the mass of the molecule was the tallest line. Very few answers stated clearly that the relative molecular mass was given by the value of the line with greatest mass/charge ratio. Answers saying that the relative molecular mass was the mass of the molecular ion were not allowed unless they explained how to find this value on the spectrum.

The most common error in calculating the formula of the alkyl group was to say it had five carbon and 12 hydrogen atoms. Some candidates had no idea how to start this part of the question.

The information in (b) showed that **Q** was a tertiary alcohol. Candidates who correctly deduced that it contained five carbon atoms sometimes drew 2,2 dimethylpropanol, a primary alcohol.

2 This question concerns the analysis of an organic compound.

(a) (i) How can the relative molecular mass of a compound be found from its mass spectrum?

(1)

Highest charge to mass ratio ~~for~~ peak in the mass spectrum

(ii) The general formula of an alcohol can be written ROH, where R is an alkyl group.

The relative molecular mass of an alcohol **Q** is 88. The formula of the alkyl group may be represented as C_xH_y.

State the values of x and y.

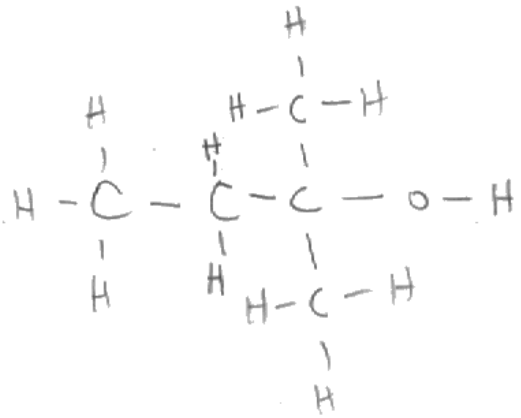
(1)

x 5 y 11

(b) When **Q** was warmed with a mixture of sulfuric acid and aqueous potassium dichromate(VI), there was no colour change.

Deduce the displayed formula of alcohol **Q**.

(1)



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Examiner Comments

This answer refers to the charge to mass ratio and was not allowed as it should be mass to charge. If it was charge to mass the peak would be the one with lowest value, but this is not how a mass spectrum is shown anyway.

Both (ii) and (iii) are correct.

ResultsPlus
Examiner Tip

Always try to check the accuracy of your answers. The ratio mass: charge is not the same as the ratio charge:mass.

(a) (i) How can the relative molecular mass of a compound be found from its mass spectrum?

(1)

By finding the average of all the results of

(ii) The general formula of an alcohol can be written ROH, where R is an alkyl group.

72

The relative molecular mass of an alcohol **Q** is 88. The formula of the alkyl group may be represented as C_xH_y.

State the values of x and y.

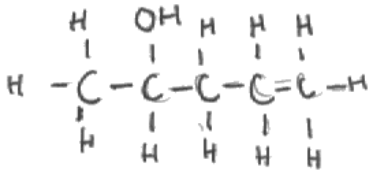
(1)

x 5 y 11

(b) When **Q** was warmed with a mixture of sulfuric acid and aqueous potassium dichromate(VI), there was no colour change.

Deduce the displayed formula of alcohol **Q**.

(1)



ResultsPlus
Examiner Comments

Many candidates seemed to confuse the mass spectrum of an element with several isotopes and the mass spectrum of a compound. Many answers described using the percentage abundance shown by each line in the spectrum to find an average value.

Part (ii) is answered correctly, but the alcohol drawn in (b) is secondary so did not score.

ResultsPlus
Examiner Tip

Make sure you know the different information which can be obtained from the mass spectrum of an element and the mass spectrum of a compound.

Alcohol **Q** must be a tertiary alcohol as it does not react with a mixture of potassium dichromate (VI) and sulfuric acid. The diagram here shows a secondary alcohol as the OH is bonded to a carbon atom which is bonded to two other carbons.

Question 2 (c)

Most candidates knew that the steamy fumes were hydrogen chloride and many could write a correct balanced equation for the reaction of hydrogen chloride with ammonia. However, only a minority knew that the state of ammonium chloride in the white smoke was solid. When this experiment is done in the laboratory the formation of a white powder is clear and should be pointed out.

(c) When a sample of **Q** was reacted with phosphorus(V) chloride, PCl_5, steamy fumes were seen.

(i) Identify these steamy fumes by name or formula.

(1)

HCl

(ii) The steamy fumes were tested by reacting them with ammonia gas. A white smoke was seen.

Write an equation, including state symbols, for the reaction in which the white smoke was formed.

(2)

$HCl_{(aq)} + NH_{3(g)} \longrightarrow NH_4Cl_{(s)}$

ResultsPlus
Examiner Comments

Hydrogen chloride gas looks steamy because it combines with moisture in the air. One way of detecting it is to breathe on it, as the moisture in breath makes it more visible. This is why the (aq) sign was allowed here as one possible answer, though (g) was expected as the description of the test referred to steamy fumes.

ResultsPlus
Examiner Tip

Smoke contains solid particles, and if you look at the bench after reacting hydrogen chloride with ammonia you may see white powder settling on it. This is the ammonium chloride.

Question 2 (d)

This question showed that many candidates were unfamiliar with interpetation of infrared spectra.

Candidates should know that different bonds cause absorption peaks at characteristic wavenumbers. The O-H bond in an alcohol will produce a peak that is not present in the spectrum of the ether.

Both alcohols and ethers contain C-O bonds, so answers saying that the C-O absorption could be used for identification were only allowed if it was clear that the C-O in an alcohol is part of C-OH whereas an ether contains C-O-C. Hence the wavenumber of the peaks differs. There was a misconception that, because ethers contain two C-O bonds, the absorption for C-O in an ether would be bigger than for the one C-O in an alcohol.

‡ (d) One of the isomers of the alcohol **Q** is an ether. Ethers contain two alkyl groups linked by an oxygen atom and can be represented as R-O-R.

Explain how the information in an **infrared** spectrum would be used to decide whether the spectrum is produced by an alcohol or an ether. Wavenumber data are not required.

(1)

The ether would not have a peak in its spectra meaning the OH group was removed. It would have a peak at a different wavenumber when the O was removed.

ResultsPlus
Examiner Comments

This response is not expressed clearly enough to score the mark. An ether would not have a peak due to the O-H bond, whereas an alcohol would.

Ethers contain an oxygen atom so O is not removed and the second sentence is therefore meaningless.

(d) One of the isomers of the alcohol **Q** is an ether. Ethers contain two alkyl groups linked by an oxygen atom and can be represented as R-O-R.

Explain how the information in an **infrared** spectrum would be used to decide whether the spectrum is produced by an alcohol or an ether. Wavenumber data are not required.

(1)

By searching for a peak ~~that~~ at a ~~wave~~ range of wavenumber that corresponds to the stretching of O–H bond

ResultsPlus
Examiner Comments

This candidate knows that the peak for the O-H bond is the key to distinguishing an alcohol and an ether, but unfortunately does not say what the presence or absence of this peak would show.

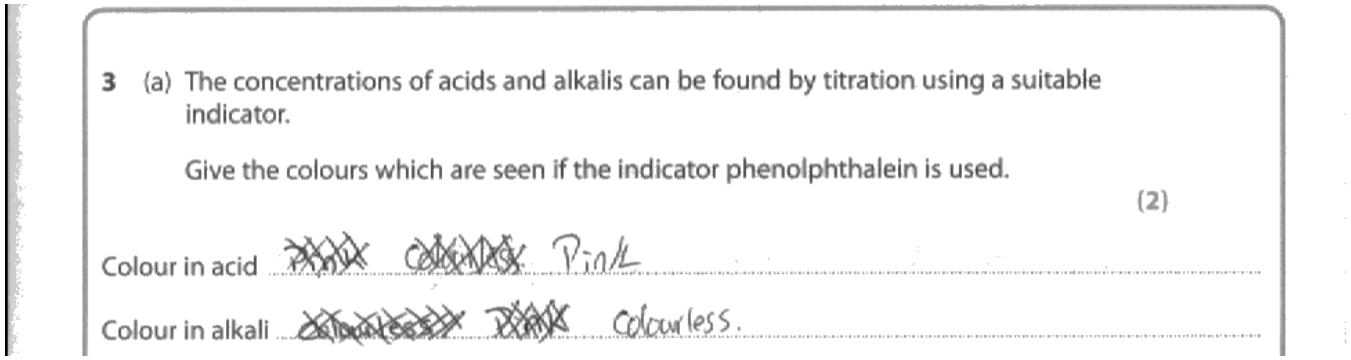
ResultsPlus
Examiner Tip

Check whether your answer fulfils the requirements of the question after you have written it.

This answer states what you should look for in the spectrum, but not how to use the information.

Question 3 (a)

Most candidates knew the colours produced by phenolphthalein, though some gave the acid and alkali colours the wrong way round.



3 (a) The concentrations of acids and alkalis can be found by titration using a suitable indicator.

Give the colours which are seen if the indicator phenolphthalein is used.

(2)

Colour in acid ~~Pink~~ Pink

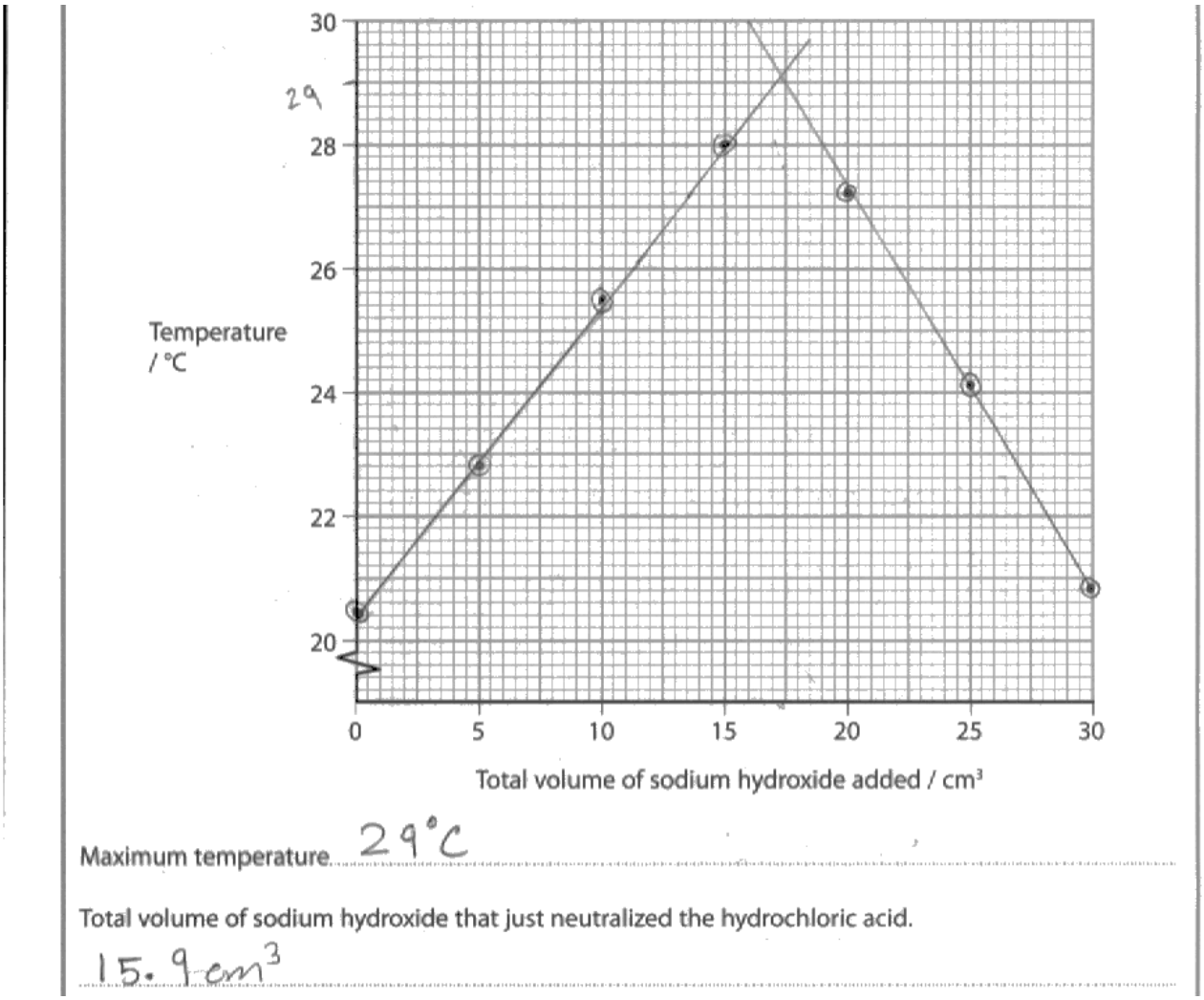
Colour in alkali ~~Colourless~~ Colourless.

ResultsPlus
Examiner Comments

Candidates could score one mark if two correct colours were given in the wrong order as happened here.

Question 3 (b)

Candidates who followed the instructions often gained all four marks here. Those who made a mistake in plotting points but drew and extrapolated the lines correctly could still score up to three marks. A common error was to read the scale of the horizontal axis wrongly when finding the volume of sodium hydroxide.



Maximum temperature 29°C

Total volume of sodium hydroxide that just neutralized the hydrochloric acid.

15.9 cm³

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Examiner Comments

This candidate has plotted the points and drawn the lines correctly but has read the horizontal scale wrongly.

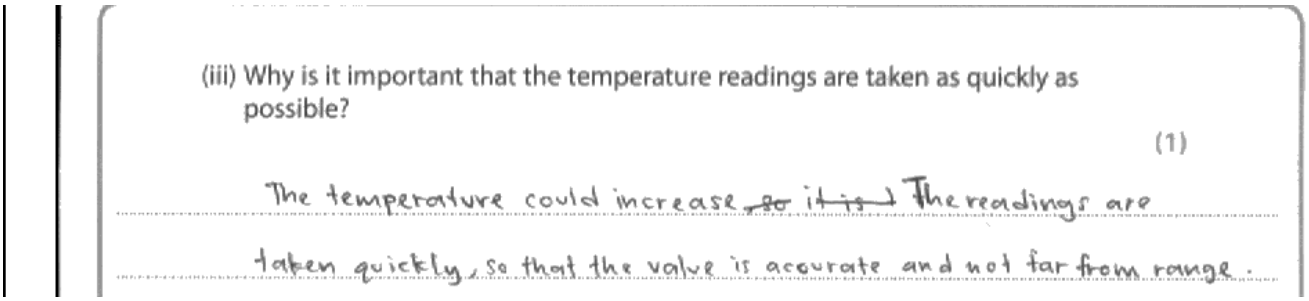
ResultsPlus
Examiner Tip

The scales on the horizontal and vertical axes are not necessarily the same so look carefully!

Question 03 (c) (iii)

Readings are taken quickly so that they are not affected by heat loss. However, this does not mean that heat losses are prevented. Candidates had to word their answers carefully to make this distinction.

Many candidates thought that readings had to be taken quickly because the reaction was fast. Reactions between ions are instantaneous but this has nothing to do with the answer to this question.



(iii) Why is it important that the temperature readings are taken as quickly as possible?

(1)

The temperature could increase, ~~so it is~~ The readings are taken quickly, so that the value is accurate and not far from range.

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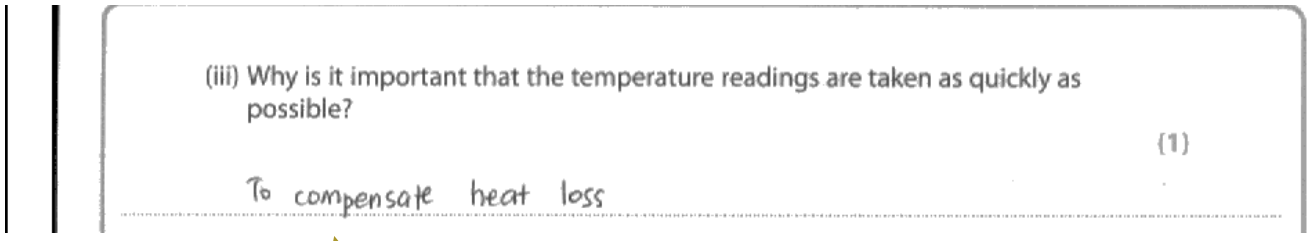
Examiner Comments

Answers like this were common but unfortunately are much too vague. The reason given for the inaccuracy when readings are taken slowly must refer to cooling.



(iii) Why is it important that the temperature readings are taken as quickly as possible?

(1)

To compensate heat loss

ResultsPlus
Examiner Comments

The word "compensate" is incorrect here. Readings should be taken before significant cooling can occur.

ResultsPlus
Examiner Tip

In some experiments two reagents are mixed and the maximum temperature is measured. Then the temperature is measured at different times and a cooling curve is drawn. This is used to calculate what the maximum temperature would have been if cooling had not occurred. Doing this allows you to compensate for heat loss.

This experiment is quite different. One reagent is added in portions and the temperature measured after each addition. Timing is not involved. The thermometric titration is used to find the end point of a titration, not to calculate an enthalpy change.

Question 3 (c) (i-ii)

In the first part of the calculation the total mass of the solution is the sum of the masses of the hydrochloric acid and the sodium hydroxide, but many candidates used the mass of sodium hydroxide only. They could still score in the second part by using their value correctly.

The final enthalpy change had to be given to three significant figures and include the minus sign but candidates often failed to score the last mark as they did not follow this instruction.

(i) Calculate the energy, in joules, transferred when the acid is just neutralized.

$$\text{Energy transferred (J)} = \text{total mass of solution (g)} \times \underset{(\text{J g}^{-1}\,^{\circ}\text{C}^{-1})}{4.18} \times \text{temperature rise } (^{\circ}\text{C})$$

Assume that the density of the solution is 1 g cm^{-3}.

(1)

Energy transferred = 20 X 4.18 X (30.6 - 20.4)

Energy transferred = 20 X 4.18 X 10.2

Energy transferred = 852.72 Joules

(ii) The number of moles of hydrochloric acid used was 3.00×10^{-2}.

Calculate the enthalpy change of the reaction, in kJ mol^{-1}, for the neutralization of one mole of hydrochloric acid.
Give your answer to **three** significant figures and include a sign.

(2)

$\frac{3.00 \times 10^{-2}}{15.50}$

$\Delta H =$ 1.935483871 x 10^{-3} kJ mol^{-1}

ResultsPlus
Examiner Comments

This candidate has based the answer on the mass of acid only. The marks in (ii) could have been scored if the answer to (i) had been used correctly.

ResultsPlus
Examiner Tip

Use the total mass of the solution which warms up when calculating the energy transferred.

The units of enthalpy change tell you how to do the calculation. The enthalpy change is the number of kJ divided by the number of moles.

(i) Calculate the energy, in joules, transferred when the acid is just neutralized.

$$\text{Energy transferred (J)} = \text{total mass of solution (g)} \times 4.18\ (\text{J g}^{-1}\ ^{\circ}\text{C}^{-1}) \times \text{temperature rise } (^{\circ}\text{C})$$

Assume that the density of the solution is 1 g cm^{-3}.

(1)

$Q = (20 + 15.50) \times 4.18 \times (30.6 - 20.4)$

$= 35.5 \times 4.18 \times 10.2$

$= 1513.578$ J

~~$= 15.13.58$ J~~

$= 1517.58$ J

(ii) The number of moles of hydrochloric acid used was 3.00×10^{-2}.

Calculate the enthalpy change of the reaction, in kJ mol^{-1}, for the neutralization of one mole of hydrochloric acid.
Give your answer to **three** significant figures and include a sign.

(2)

$\Delta H^{\circ}_{\text{neutralisation}} = \dfrac{1.51358\ \text{kJ}}{3.00 \times 10^{-2}\ \text{mol}}$

$= -504.53\ \text{kJ mol}^{-1}$

$\Delta H =$ -504.53 kJ mol^{-1}

ResultsPlus
Examiner Comments

This candidate knew how to do the calculation but unfortunately did not give the final answer to the required number of significant figures.

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Examiner Tip

You will lose a mark if you do not give your answer to the required number of significant figures, and you should know the difference between significant figures and decimal places.

Remember that you need to include the sign of the enthalpy change after deciding whether the reaction is exothermic or endothermic.

Question 3 (c) (iv)

In many answers there were comments about reducing human error, avoiding parallax errors or saving time in plotting graphs and none of these answers scored. Use of an electronic probe means that temperature is monitored continuously. This is equivalent to having more points to plot, and it is this that makes the use of the graph more accurate.

The magnetic stirrer ensures that the temperature and concentration of the mixture are uniform. The stirrer does not reduce heat loss, as many answers claimed.

The thermometric titration described in (b) used a well-insulated cup, so the use of an insulated beaker in the computer experiment was also irrelevant, though it was often suggested.

Explain why this modified method can give improved results, other than because of any increase in accuracy of the temperature readings by the electronic probe.

(2)

Because the graph will be automatically produced to determine the theoritical temperature rise and straight anomalies can be detected from the graph. The data also will be large in scale and ~~earlier~~ make the data more reliable.

$NaOH + HCl \rightarrow NaCl + H_2O$

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Examiner Comments

Continuous monitoring is equivalent to having many more readings than would be obtained by simply measuring temperature after adding portions of alkali. This idea is not clear enough in this answer.

Explain why this modified method can give improved results, other than because of any increase in accuracy of the temperature readings by the electronic probe.

(2)

Data of temperature can be collected quickly and in greater accuracy so that no heat is loss to the surroundings in an extended period of time. Errors due to parallax errors when reading the temperature can be avoided.

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Examiner Comments

This answer was allowed a mark for the idea that data is collected without any time delay, hence reducing errors due to heat loss.

The question said that reasons for the improved results should be on factors other than any increase in accuracy of temperature readings, so the comment on parallax errors did not score.

Question 3 (d) (i)

The calculation was often carried out correctly.

Some candidates only got as far as calculating that 0.03 mol of hydrochloric acid were used. This gained the first mark as long as it was clear what was being calculated but seeing the number "0.03" without any context was not good enough. Candidates should be encouraged to show what they are working out in each stage of their calculations. This helps them to proceed logically, to check a calculation, and gives them a chance of gaining part marks even if there is a mistake at some stage.

(d) (i) Calculate the concentration, in mol dm^{-3}, of the sodium hydroxide used when 20.0 cm^3 of 1.50 mol dm^{-3} hydrochloric acid is neutralized by 15.50 cm^3 of sodium hydroxide.

(2)

moles of HCl = $1.5 \times \frac{15.5}{1000}$ = 0.0234 moles

molar ratio is 1:1

∴ mols of NaOH = 0.0234 moles

Concentration = $\frac{0.0234}{0.02}$

= 1.17 mol dm^{-3}

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Examiner Comments

This answer is very clearly set out but unfortunately the candidate has used the volume of alkali where the volume of acid was needed and vice versa.

ResultsPlus
Examiner Tip

Check your working to make sure you are using the right data.

(d) (i) Calculate the concentration, in mol dm^{-3}, of the sodium hydroxide used when 20.0 cm^3 of 1.50 mol dm^{-3} hydrochloric acid is neutralized by 15.50 cm^3 of sodium hydroxide.

(2)

$n(HCl) = 20 \times 10^{-3} \times 1.5 \text{ mol dm}^{-3} = 0.03 \text{ mol}$.

$n(HCl) = n(NaOH)$

$C(NaOH) = \frac{n}{V} = \frac{0.03 \text{ mol}}{15 \times 10^{-3} \text{ dm}^3} = 2 \text{ mol dm}^{-3}$.

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Examiner Comments

This candidate calculated the number of moles of acid and alkali correctly and scored the first mark. However, the final answer should not have been rounded to one significant figure.

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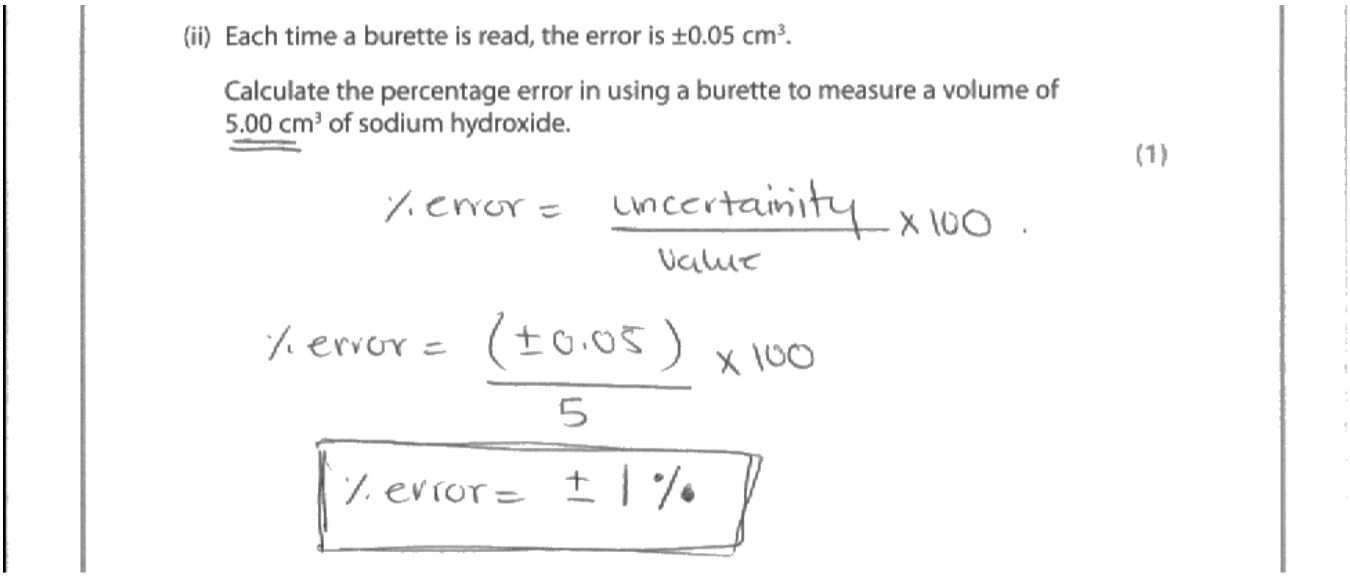
Examiner Tip

When you are given data to three significant figures you should not round your final answer to one significant figure. In this question the appropriate concentration was 1.94.

Question 3 (d) (ii)

The question provided the hint that there was an error each time a burette is read. This means that the value ± 0.05 in each reading had to be multiplied by two when calculating the percentage error.



(ii) Each time a burette is read, the error is ±0.05 cm³.

Calculate the percentage error in using a burette to measure a volume of 5.00 cm³ of sodium hydroxide.

(1)

% error = $\frac{\text{uncertainity}}{\text{value}} \times 100$

% error = $\frac{(\pm 0.05)}{5} \times 100$

% error = ± 1 %

ResultsPlus
Examiner Comments

This candidate shows the method clearly but has omitted the factor of 2.

ResultsPlus
Examiner Tip

When you measure a volume with a burette you have to take the reading at the start and when you finish. This means the error is double the error in each reading.

Question 3 (e) (i)

In thermometric titrations, concentrated solutions are used so that the temperature change will be reasonably large. This means that the error in the temperature change will be reduced.

Many candidates again thought the reason was to make the reaction faster and avoid heat loss. Some correctly deduced that lower volumes of solution could be used, but then incorrectly said that this would reduce error in measurement of volume.

(e) (i) When a titration is carried out using an indicator, the concentrations of acid and alkali are usually between 0.05 and 0.20 mol dm^{-3}.

Explain why more concentrated solutions are used in thermometric titrations.

(1)

Higher concentration increases the accuracy of results as it reduces percentage error.

ResultsPlus
Examiner Comments

This comment is true but does not go far enough as it does not say which percentage error is reduced.

(e) (i) When a titration is carried out using an indicator, the concentrations of acid and alkali are usually between 0.05 and 0.20 mol dm^{-3}.

Explain why more concentrated solutions are used in thermometric titrations.

(1)

To increase temperature change so it ~~less~~ error due to ~~mass~~ temperature reading can be reduce

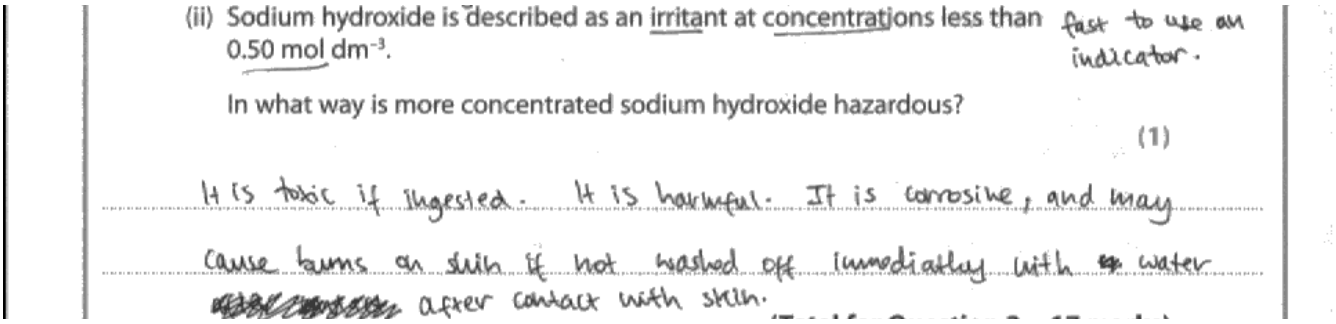
ResultsPlus
Examiner Comments

This is an example of a good answer.

Question 3 (e) (ii)

Candidates who give a list of suggestions in a question like this will not score if some answers are correct and others are wrong. Concentrated sodium hydroxide is corrosive, but an answer saying it is inflammable and corrosive would not have been given the mark.

Some answers said that more concentrated sodium hydroxide is more irritant, but this is not good enough. In the hazard warning system, substances which are harmful or irritant are distinguished from those which are corrosive.



(ii) Sodium hydroxide is described as an irritant at concentrations less than 0.50 mol dm^{-3}.

fast to use an indicator.

In what way is more concentrated sodium hydroxide hazardous?

(1)

It is toxic if ingested. It is harmful. It is corrosive, and may cause burns on skin if not washed off immediately with water after contact with skin.

ResultsPlus
Examiner Comments

Candidates should be advised not to make a list of different answers like this, as the mark was not allowed.

Concentrated sodium hydroxide is very corrosive. If ingested it would be damaging because of this, so the answer toxic was not allowed.

Theoretically it could be neutralised by stomach acid but damage would be caused before reaching the stomach.

ResultsPlus
Examiner Tip

In a question like this you should choose the main hazard of concentrated sodium hydroxide and not give a list of suggestions.

Question 4 (a)

The colour change which occurs when acidified potassium dichromate(VI) reacts with an alcohol was well known.

(a) What colour change will be seen when the acidified sodium dichromate(VI) reacts with the butan-2-ol?

(1)

From green to orange

ResultsPlus
Examiner Comments

The most common error was to get the colour change the wrong way round.

Question 4 (b)

Few candidates seemed to read the introduction to the question carefully. The introduction and procedure stated that a solvent with a lower boiling temperature than butanone was used in the preparation, and gave the actual boiling point as between 32°C and 36°C. The reaction mixture is kept cool to avoid escape of this solvent. However, if candidates clearly stated the principle that the ice and water bath was used to prevent evaporation, and hence loss, of one of the organic compounds the mark was allowed. A thoughful candidate would have realised that butan-2-ol would have an even higher boiling temperature than butanone and hence be less likely to evaporate. Evaporation and loss of the acid were not allowed.

Other answers immediately associated lower temperature with lower rate of reaction, and said, incorrectly, that the ice and water bath was used to slow down the reaction.

In questions describing practical procedures, it is important to read the experimental details carefully. There is a reason for carrying out the experiment in a particular way and the reasons for using the method should be understood.

(b) The reaction is exothermic. Other than the risk of explosion, why is it important to cool the flask in a beaker of ice and water in **step 2**?

(1)

This is done to ~~mak~~ reduce the rate of reaction and ~~make it~~ the less ~~exothermic~~ heat ~~release~~ reducing the ~~heating~~ heating effect. Therefore it is easier to handle and there is no risk of burning your hand. This will also prevent conc. H_2SO_4 from being ~~spitted~~ spit out of the flask - thereby providing protection.

ResultsPlus
Examiner Comments

Some candidates incorrectly thought the reaction should be slowed down, or thought it was an exothermic equilibrium reaction which would give a higher yield at low temperatures.

ResultsPlus
Examiner Tip

Each piece of information in the procedure is important so you should read it very carefully.

This reaction proceeds without heating and the mixture is kept cool to stop the very flammable solvent vapourising.

(b) The reaction is exothermic. Other than the risk of explosion, why is it important to cool the flask in a beaker of ice and water in **step 2**?

(1)

the organic solvent has a low boiling temperature and the alcohol is flamable

ResultsPlus
Examiner Comments

The substance most likely to catch fire is the solvent so this was not given a mark.

The fact that the solvent has a low boiling point was not developed in to an explanation that it would therefore vapourise and escape easily.

Question 4 (c)

Not many candidates scored all three marks for this question.

The purpose of washing with sodium hydrogen carbonate solution is to neutralise any excess acid. Candidates who said the butanone was neutralised were not given the mark, and the popular answer that "it would remove impurities" did not score either. Candidates should not give a list of alternative answers, as this shows they do not really know what is needed.

Washing is carried out in a separating funnel, and the carbon dioxide formed in the reaction has to be released at intervals to avoid pressure building up. Many candidates were not familiar with this technique and there were all sorts of suggestions such as carrying out titrations, filtering, distilling etc.

(c) State the purpose of washing the crude butanone in **step 4** with sodium hydrogencarbonate solution. Describe the method used to carry out this process, naming the piece of apparatus used.

(3)

Purpose To remove acid

Method A seperating funnel is used. Sodium hydrogen carbonate is added to remove any acid present. This releases carbon dioxide gas. So after ~~sh~~ inverting the flask a few times to mix the reactants, the bung is removed to let go of any carbon dioxide produced to prevent the build up of pressure.

ResultsPlus

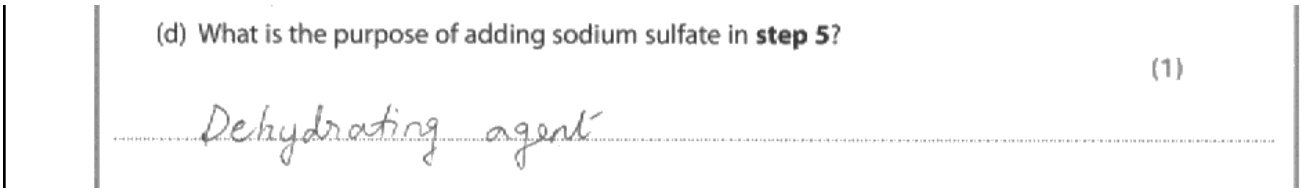
Examiner Comments

This is an example of an answer which scored full marks. Some candidates referred to opening the tap to run off one of the layers, but opening the tap to release the pressure had to be described to score all the marks.

Question 4 (d)

Sodium sulfate is a drying agent, and candidates could state this or say it is used to remove water.

Many answers said that it removed impurities, which is not specific enough in this case.


(d) What is the purpose of adding sodium sulfate in **step 5**?

(1)

Dehydrating agent

ResultsPlus
Examiner Comments

The answer "dehydrating agent" was not allowed as dehydration involves a chemical reaction in which the elements of water are removed from a molecule.

ResultsPlus
Examiner Tip

You should learn the difference between dehydration and drying.

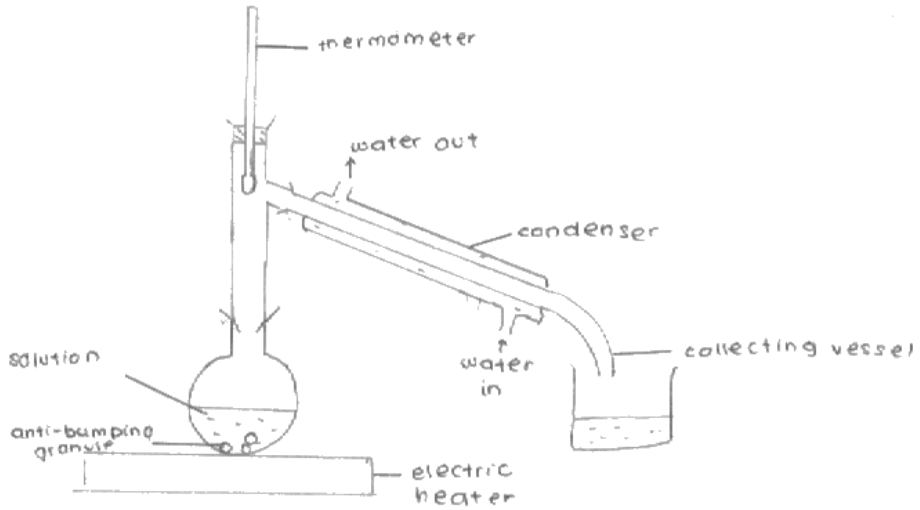
Question 4 (e)

The purpose of this distillation was to remove a solvent which is extremely flammable and has a low boiling temperature. This distillation should not be carried out with a naked flame, so one precaution is use of an electric heater or a water bath. Other possibilities were to lead any uncondensed solvent vapour well away from the flame through a tube after the condenser, or to collect the distillate in a flask surrounded by an ice bath.

Candidates who have seen and used condensers should know that the distillate in the inner tube is completely separated from the outer water jacket. Diagrams often show apparatus where the water would mix with the distillate. The condenser should slope downwards to the collection flask, but a significant number were drawn in a horizontal position. Drawings of reflux condensers were rare.

(e) Draw a labelled diagram of the apparatus used in **step 6** to distil off the solvent from the organic layer. The diagram should show at least one precaution which must be taken when distilling an extremely flammable liquid.

(4)



ResultsPlus
Examiner Comments

This is an example of an answer which scored full marks.

ResultsPlus
Examiner Tip

Note the correct position of the thermometer bulb and the way the condenser is drawn. Mistakes are often made in these two parts of the diagram and this example shows how to draw them correctly.

Question 4 (f) (i)

Most candidates knew that the volume was calculated by dividng the mass of the liquid by its density. In incorrect answers mass and density were often multiplied.

Question 4 (f) (ii)

There were many different routes through this calculation, but the three things which had to be calculated at some stage were the number of moles of butanone in 3.00g, an adjustment for the 64% yield and the final mass of butan-2-ol.

The most common error was in dealing with the 64%. Candidates could start by calculating the theoretical yield which would have to be greater than 3.00g, but frequently they calculated 64% of 3.00 which is a smaller mass.

The candidates who started by calculating the moles of butanone in 3.00g should also then have calculated that the theoretical yield would have to be more than this value.

Many candidates correctly calculated that 3.082g butan-2-ol would theoretically produce 3.00g butanone and then found 64% of this mass.

The answers were often extremely difficult to follow. Candidates should write a few words with each number they calculate eg "mol butanone = ..." This would assist them to see what they were doing and make it more likely that they scored partial marks if an error occurred at some stage.

(ii) Each mole of butan-2-ol can produce a maximum yield of one mole of butanone.

Calculate the mass of butan-2-ol that would be required to make 3.00 g of butanone if the yield is 64%.

Relative molecular masses:

butan-2-ol	74.1
butanone	72.1

(3)

$n_{butanone} = \frac{m}{Mr} = \frac{3}{72.1}$

$= 0.0416$ mol

butan-2-ol : butanone

1 mol : 0.64 mol

x : 0.0416 mol

$x = \frac{0.0416}{0.64}$

$= 0.065$ mol

$m_{butan-2-ol} = n \times Mr$

$= 0.065 \times 74.1$

$= 4.82$ g are required

ResultsPlus

Examiner Comments

This calculation is well set out and easy to follow. It scored full marks. The candidate did not round numbers too early and did the percentage calculation correctly.

(ii) Each mole of butan-2-ol can produce a maximum yield of one mole of butanone.

Calculate the mass of butan-2-ol that would be required to make 3.00 g of butanone if the yield is 64%.

Relative molecular masses:

butan-2-ol	74.1
butanone	72.1

(3)

74.1g × 0.64 = 47.424

m × 0.64 = 3

$\frac{3}{0.64} = m$

m = 4.6875

= 4.6875g

= 4.69g.

ResultsPlus

Examiner Comments

This candidate has done calculations using various numbers in the question without any indication of the purpose of each step.

The value of 4.69 is the theoretical mass of butanone which would give 3.00g at 64% yield. It is not a mass of butan-2-ol so does not make sense as a final answer.

Paper Summary

There were frequent examples of answers where the question had not been read carefully. The requirement to give the enthalpy change in 3(c)(ii) with three significant figures and a sign was one where a mark was often lost.

Candidates would benefit from more practice in interpreting mass spectra and infrared spectra and making deductions from them.

Many candidates are unsure about the number of significant figures to use in numerical work. The general rule is to give answers with the same number of significant figures as the data, and not to round answers too early in a calculation with several stages.

Hints for candidates

- Always read the question carefully. Show the method in your calculations and try not to use too many or too few significant figures.
- When you are working in a laboratory think about what you are doing and why you are doing it. There is much more to laboratory work than just making observations or taking readings.
- Have a good look at a Liebig condenser, and when you draw it show that the inner tube is completely separated from the water in the outer tube.

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