

Examiners' Report
January 2012

GCE Chemistry 6CH07 01

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Introduction

The style and standard of this paper were similar to previous series. The paper had many straightforward questions which were accessible to all candidates, but there were challenges for the most able candidates, especially in questions where explanation of the reasoning behind experimental techniques was required. Candidates sometimes know what to do in an experiment, but do not understand the chemistry behind the procedure.

The questions involving calculations were often done correctly. Only one question specified the number of significant figures required in the answer, and in other cases the number of significant figures was ignored during marking unless there were many fewer figures than in the data provided. However, candidates often made errors when rounding their answers and, no matter how many significant figures are quoted, the answer should be rounded correctly. Incorrect rounding can make a real difference when a number is carried forward into a second stage of a calculation.

Some candidates give alternative answers to a question, and they should be aware that if one of these is wrong the correct answer will not gain credit.

Question 1 (a)

Most candidates answered this correctly. A few candidates gave the correct answer and also an alternative which was wrong, and in this case the mark was not awarded.

Some candidates referred to a lilac precipitate forming, which was not allowed.

Question 1 (b) (c) (d)

The ion in (b) was sometimes named as iodine instead of iodide. This was not accepted unless the correct formula was also given. A significant proportion of candidates who identified the ion correctly thought that the precipitate would dissolve in dilute ammonia.

Several different answers were accepted for the colour of bromine in (c) as the colour varies with concentration. However when bromine is added to a solution of potassium iodide it will cause iodine to be displaced, and the colour given for iodine had to be darker than the one given for bromine. Potassium bromide will also form, but this was not allowed for the mark as it is not responsible for the colour change. A number of candidates gave blue-black as the colour of iodine, but this only applies in the presence of starch. Many candidates did not think enough about the products of the reaction and said that the bromine would be decolorised and an alkene was present.

Knowledge of the products of the reaction of potassium iodide and concentrated sulfuric acid in (d) was not good, and answers such as carbon (for the black solid) and potassium or one of its compounds appeared quite often.

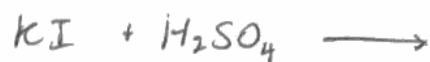
- 1 A series of tests was carried out on A, a white powder, which is known to contain one cation and one anion. Complete the table below. You may use names or formulae in your answers.

Test	Observations	Inferences
(a) Carry out a flame test on A.	lilac flame	Cation is potassium
(b) Add a mixture of dilute nitric acid and aqueous silver nitrate to an aqueous solution of A. Then add an excess of dilute aqueous ammonia to the mixture.	A yellow precipitate forms. When excess dilute aqueous ammonia is added Partially dissolves in dilute aqueous ammonia	Anion is I^-
(c) Add an aqueous solution of bromine to an aqueous solution of A.	The colour of the solution of bromine is Brown When bromine is added to an aqueous solution of A the colour of the mixture is decolourized	The change in colour is due to the formation of Cl⁻ Br^-

Test	Observations	Inferences
(d) Add concentrated sulfuric acid to a solid sample of A.	A vigorous reaction occurs producing a black solid, a yellow solid, a gas with an unpleasant smell and some coloured fumes.	The black solid is I_2 (cs) and the yellow solid is K_2O (cs)

(2)

(Total for Question 1 = 8 marks)



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Examiner Comments

In (c) the answer that bromine is decolorised was given frequently.



ResultsPlus

Examiner Tip

When bromine is used to test for an alkene it is decolorised. In reactions with halides displacement reactions occur and you need to work out what products form, and their colours.

- 1 A series of tests was carried out on A, a white powder, which is known to contain one cation and one anion. Complete the table below. You may use names or formulae in your answers.

Test	Observations	Inferences
(a) Carry out a flame test on A.	<p>.....</p> <p>..... Li⁺</p> <p>.....</p>	Cation is potassium
(b) Add a mixture of dilute nitric acid and aqueous silver nitrate to an aqueous solution of A.	<p>A yellow precipitate forms.</p> <p>.....</p> <p>.....</p> <p>When excess dilute aqueous ammonia is added</p> <p>..... nothing happens as it's</p> <p>..... only soluble in CONCENTRATED</p> <p>..... ammonia</p> <p>.....</p>	Anion is iodide iodine
(c) Add an aqueous solution of bromine to an aqueous solution of A.	<p>The colour of the solution of bromine is</p> <p>..... orange-brown</p> <p>When bromine is added to an aqueous solution of A the colour of the mixture is</p> <p>..... dark brown</p>	<p>The change in colour is due to the formation of</p> <p>..... iodine hydrogen iodide</p> <p>..... bromide</p>

Test	Observations	Inferences
(d) Add concentrated sulfuric acid to a solid sample of A.	A vigorous reaction occurs producing a black solid, a yellow solid, a gas with an unpleasant smell and some coloured fumes.	The black solid ispotassium iodide..... and the yellow solid is

(2)



ResultsPlus

Examiner Comments

The name iodine was not accepted for the mark in (b) instead of iodide. The colours given in (c) were allowed as they indicated that the solution was getting darker.



ResultsPlus

Examiner Tip

Bromine causes a displacement reaction with potassium iodide. As hydrogen bromide is a steamy gas it could not cause a colour change in a solution.

Question 2

Most candidates knew that the yellow flame was due to the sodium ion. A name or formula could be given in the answer, but if a formula was chosen it had to be correct to gain the mark, and this meant the correct charge had to be shown. Candidates had more difficulty with (b) and often suggested the precipitates were sodium salts, or just gave the ions. Another common error was to suggest the precipitate was barium sulfite. More careful reading of the question was needed here, as the original compound was stated to contain carbonate or sulfate ions. Many correct answers were given to (c), although again sulfites and sulfur dioxide were common mistakes. A mark was given in (d) if the answer was consistent with the cation and anion suggested.

- 1 A series of tests was carried out on A, a white powder, which is known to contain one cation and one anion. Complete the table below. You may use names or formulae in your answers.

	Test	Observations	Inferences
(a)	Carry out a flame test on A.	lilac flame	Cation is potassium
(b)	Add a mixture of dilute nitric acid and aqueous silver nitrate to an aqueous solution of A. Then add an excess of dilute aqueous ammonia to the mixture.	A yellow precipitate forms. When excess dilute aqueous ammonia is added Partially dissolves in dilute aqueous ammonia	Anion is I^-
(c)	Add an aqueous solution of bromine to an aqueous solution of A.	The colour of the solution of bromine is Brown When bromine is added to an aqueous solution of A the colour of the mixture is decolourized	The change in colour is due to the formation of Br⁻ Br^-

ResultsPlus Examiner Comments

The question said that B contained carbonate or sulfate ions. No sulfite was involved.

ResultsPlus Examiner Tip

If a precipitate has to be identified, the full name of the compound is needed, not just one of the ions in it. Barium sulfate would have got a mark in (b).

- 2 A series of tests was carried out on a compound, **B**, which is known to contain **either** carbonate or sulfate (sulfate(VI)) ions as well as one cation.

Complete the inferences column. You may use names or formulae in your answers.

	Test	Observations	Inferences	
(a)	Carry out a flame test on B .	Yellow flame.	The cation in B is Na^+	(1)
(b)	Add aqueous barium chloride solution to an aqueous solution of B .	A white precipitate forms.	The precipitate could be either $NaCl$ or $Ba_2(CO_3)_2$	(2)
(c)	Add dilute hydrochloric acid to the mixture formed in (b) until there is no further change.	Some fizzing occurs and the precipitate dissolves.	The anion in B is CO_3^{2-} and the fizzing is due to formation of CO_2	(2)

- (d) The formula of **B** is

(1)



ResultsPlus Examiner Comments

The answer to (b) shows that this candidate was thinking about the products of reacting sodium carbonate and barium chloride, not about solubilities.



ResultsPlus Examiner Tip

If you have a choice of giving a name or formula there is often less chance for error in giving the name. In (b) barium carbonate is precipitated, but the formula should not be written like this.

Question 3 (a)

Only a small proportion of candidates stated that the reason for using a powder in an experiment to measure a temperature change is to avoid errors due to cooling. It was more usual to say that the powder causes a fast reaction, and the mark was allowed for stating this.

If lumps of magnesium carbonate are reacted with an excess of acid they would all react eventually, so answers saying that not all the carbonate would react were not allowed.

3 Magnesium carbonate reacts with dilute nitric acid as shown in the equation below.



The enthalpy change for this reaction can be determined as follows:

Procedure

1. Weigh 3.50 g of finely powdered magnesium carbonate.
2. Transfer 50.0 cm³ of 2.00 mol dm⁻³ nitric acid into a polystyrene cup and record the temperature of the acid.
3. Add the magnesium carbonate to the nitric acid.
4. Stir the mixture and record the maximum temperature reached.

Results

Temperature of nitric acid before addition of magnesium carbonate	21.0 °C
Final temperature of solution	29.7 °C

(a) Explain why the magnesium carbonate used in this experiment should be finely powdered rather than in lumps.

(1)

To increase surface area in contact with acid.
to the surroundings
This ensures less heat loss as the reaction
takes place faster and completes faster.

(b) (i) Calculate the number of moles of magnesium carbonate in 3.50 g



ResultsPlus
Examiner Comments

This is a very good, full answer.

- 3 Magnesium carbonate reacts with dilute nitric acid as shown in the equation below.



The enthalpy change for this reaction can be determined as follows:

Procedure

1. Weigh 3.50 g of finely powdered magnesium carbonate.
2. Transfer 50.0 cm³ of 2.00 mol dm⁻³ nitric acid into a polystyrene cup and record the temperature of the acid.
3. Add the magnesium carbonate to the nitric acid.
4. Stir the mixture and record the maximum temperature reached.

Results

Temperature of nitric acid before addition of magnesium carbonate	21.0 °C
Final temperature of solution	29.7 °C

- (a) Explain why the magnesium carbonate used in this experiment should be finely powdered rather than in lumps.

(1)

Ensure all magnesium carbonate is reacted with HNO₃, due
to increase of contact surface area.



ResultsPlus Examiner Comments

For accurate results all of the magnesium carbonate has to react with the acid, and it must react quickly. The point about rate is not made here.

Question 3 (b)

Most candidates could calculate the number of moles of magnesium carbonate correctly. To assist with the calculation, the mass of 1 mole of magnesium carbonate was given as 84. The answer should therefore not have been given to less than 2 significant figures, and 0.04 was not accepted. It looks as if many candidates do not think about a sensible number of significant figures to quote, or they may not understand the difference between a number of significant figures and a number of decimal places. It is better not to round off an answer too much if it is going to be used for a further calculation. There was no requirement here for a particular number of significant figures, but quoting a full calculator read out is not good practice, even if it is held in the calculator for a further calculation.

The number of moles of acid was more than double the number of moles of magnesium carbonate and therefore in excess. Some candidates said that the magnesium carbonate would react with 0.0834 moles of acid but did not gain the mark as they gave no comment on why 0.100 moles of acid was suitable. Others said that "the amount of acid is enough to react", which is not the same as being in excess. Some clearly thought the mole ratio in the reaction was 1:1, but got the mark if they realised the importance of having the acid in excess.

(b) (i) Calculate the number of moles of magnesium carbonate in 3.50 g.

[Assume the molar mass of magnesium carbonate is 84 g mol^{-1} .]

(1)

$$\begin{aligned} \text{mol of MgCO}_3 &= \frac{3.50}{84} \\ &= 0.04167 \text{ mol} \end{aligned}$$

(ii) The volume of dilute nitric acid used contained 0.100 mol of HNO_3 . Suggest why this amount is suitable.

(1)

One reactant must be in excess for reaction to go to completion.



ResultsPlus Examiner Comments

The value in (i) is rounded correctly for the number of significant figures which have been given.

In (ii) the answer does not say which reactant is in excess.

(b) (i) Calculate the number of moles of magnesium carbonate in 3.50 g.

[Assume the molar mass of magnesium carbonate is 84 g mol^{-1} .]

(1)

$$\text{Moles} = \frac{3.5}{84} = 0.42 \text{ moles.}$$

(ii) The volume of dilute nitric acid used contained 0.100 mol of HNO_3 . Suggest why this amount is suitable.

(1)

This much amount is enough to neutralize carbonates



ResultsPlus

Examiner Comments

This candidate has made an arithmetical error in (i) and omitted a zero before the 4. In (ii) it is not clear that the acid is in excess.

Question 3 (c)

Most candidates were able to calculate the energy transferred in (i). Only a few incorrectly used 53.5 as the mass of the solution. Many knew how to calculate the enthalpy change in (ii). Marks were often lost when the negative sign was forgotten or when more than the required three significant figures were given in the final answer.

- (c) (i) Calculate the heat energy transferred, in joules, in this reaction between magnesium carbonate and nitric acid.

Use the expression

$$\text{energy transferred (J)} = \text{mass of solution} \times \text{specific heat capacity of solution} \times \text{temperature rise}$$

[Assume the mass of solution is 50 g and its specific heat capacity is $4.18 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$.]

(1)

$$\begin{aligned} \text{Energy transferred (J)} &= 50 \text{ g} \times 4.18 \times 8.7^\circ\text{C} \\ &= \boxed{1818.3 \text{ Joules}} \end{aligned}$$

$$\begin{array}{r} 29.7 \\ -21.0 \\ \hline 08.7 \end{array}$$

- (ii) Calculate the enthalpy change, ΔH , for the reaction of one mole of magnesium carbonate with nitric acid. Your answer should be in units of kJ mol^{-1} , expressed to **three** significant figures, and include a sign.

(2)

$$\Delta H = \frac{\text{Energy transferred}}{\text{No. of moles}} = \left(\frac{1818.3}{1000} \right) = \frac{1.82 \text{ kJ}}{3} = -0.607 \text{ kJ mol}^{-1}$$

$$0.1 + 0.042$$

1 mole of Magnesium = 2 moles of nitric acid

3 moles in total



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Examiner Comments

The calculation in (i) is correct. In (ii) the candidate has used the number of joules calculated as if they had been produced by one mole of magnesium carbonate, not the 0.0417 moles which were actually used.

- (c) (i) Calculate the heat energy transferred, in joules, in this reaction between magnesium carbonate and nitric acid.

Use the expression

$$\text{energy transferred (J)} = \text{mass of solution} \times \text{specific heat capacity of solution} \times \text{temperature rise}$$

[Assume the mass of solution is 50 g and its specific heat capacity is $4.18 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$.]

(1)

$$\begin{aligned} \Rightarrow \Delta H &= MC\Delta T \\ \Rightarrow \Delta H &= 50 \times 4.18 \times 8.7 \\ \Rightarrow \Delta H &= \underline{\underline{1818.3 \text{ J}}} \end{aligned}$$

- (ii) Calculate the enthalpy change, ΔH , for the reaction of one mole of magnesium carbonate with nitric acid. Your answer should be in units of kJ mol^{-1} , expressed to **three** significant figures, and include a sign.

$$\begin{aligned} \Rightarrow & \text{50g of solution requires } 1818.3 \text{ J of energy.} \\ \Rightarrow & \therefore \text{1g of solution requires } x \text{ J of energy.} \\ \Rightarrow & \frac{1818.3 \times 84.3}{50} \\ \Rightarrow & 3065.65 \text{ J} \\ \Rightarrow & \underline{\underline{+3.066 \text{ kJ}}} \text{ (Endothermic)} \end{aligned} \quad (2)$$



ResultsPlus Examiner Comments

The calculation in (i) is correct.

In (ii) the calculation is based on the mass of the solution, not the number of moles of magnesium carbonate. Also it has not been given the correct sign and is quoted to three decimal places, not three significant figures.



ResultsPlus Examiner Tip

Make sure you know the difference between a number given to three significant figures and a number given to three decimal places.

Question 3 (d)

As the question was about practical advantages of using a pipette or measuring cylinder, answers about cost were not allowed. Some candidates said that measuring cylinders were less accurate than pipettes which, though true, is not an advantage. Many answers quoted a value for the accuracy of a pipette without saying whether it was more or less accurate than a measuring cylinder. Others stated that both instruments were more accurate.

A small but significant number of responses indicated that the candidates thought pipetting by mouth was an acceptable technique. Candidates are expected to use safety fillers whenever they use pipettes.

In the calculation of percentage error, candidates frequently multiplied the total error, given as ± 0.01 , by 2. This multiplication is needed in the case when two separate readings are taken, such as in measuring the difference between two burette readings, but it was incorrect here. Even when calculated correctly the percentage error was often incorrectly rounded from 0.28571 to 0.28.

- (d) (i) The nitric acid for this experiment could be measured using either a pipette or a measuring cylinder. Give one practical advantage of using each piece of apparatus. (2)

Pipette is suitable ~~for~~ ^{for} measuring solutions in small quantity such as 0.05 cm³

Measuring cylinder is suitable for measuring solutions in a large quantity such as 10 cm³

- (ii) The total error in measuring the mass of the magnesium carbonate was ± 0.01 g. Calculate the percentage error in the weighing. (1)

$$\begin{array}{l} - 3.5\text{g} \\ 3.5 + 0.01 = 3.51 \\ \cancel{3.5} - 3.5 - 0.01 = 3.49 \end{array} \qquad \begin{array}{l} 3.51 - 3.49 \\ = 0.2 \\ \frac{0.2}{3.5} \times 100 \\ = 5.71428 \\ \approx 5.7\% \end{array} \qquad (1)$$



ResultsPlus Examiner Comments

The question said that either a pipette or measuring cylinder could be used in this experiment, but many candidates thought that pipettes were used only for very small volumes.

The calculation in (ii) has doubled the total error and also made an arithmetical error.



ResultsPlus Examiner Tip

Two readings are taken when a burette is read, so the total error is the error in each reading multiplied by two. The total error was given in this question.

- (d) (i) The nitric acid for this experiment could be measured using either a pipette or a measuring cylinder. Give **one** practical advantage of using each piece of apparatus. (2)

Pipette ~~user~~ Using a smaller scale, measurement of volume of nitric acid is more accurate.

Measuring cylinder Using a larger scale, percentage error is minimized.

- (ii) The **total error** in measuring the mass of the magnesium carbonate was ± 0.01 g. Calculate the percentage error in the weighing. (1)

$$\begin{aligned}\text{Percentage error} &= \frac{2(0.01)}{3.5} \times 100\% \\ &= \underline{\underline{0.57\%}}\end{aligned}$$



ResultsPlus
Examiner Comments

One mark was given in (i) for the idea that a pipette was more accurate.

In (ii) the total error should not have been doubled.

Question 3 (e)

The correct way to describe the effect on the enthalpy change of an exothermic reaction is to say that it becomes more or less negative. Most candidates referred to the enthalpy changes as getting smaller or larger, and this is very ambiguous when referring to a negative number as, for example, -50 is a lower number and therefore mathematically smaller than -40. It was often difficult to decide what answers meant, as they frequently contained conflicting comments. Many candidates stated that copper was a better conductor of heat than polystyrene, so more heat would escape to the surroundings. Some then said that the temperature of the surroundings would therefore be greater with the copper can (true but irrelevant) so the enthalpy change was greater (only true if they meant less negative). Candidates who tried to give an explanation based on the specific heat capacity of copper often went wrong, and confused the specific heat of copper and its ability to conduct heat.

The reasoning used to explain the effect on the enthalpy change was more often correct in the first part of this question than in the second part. If the 3.5g sample of powder is damp, then the number of moles of magnesium carbonate present is less than in a dry sample, so the enthalpy change will be less negative. However, many candidates were sidetracked here and talked about hydrolysis of magnesium carbonate or the rate of the reaction, or even the energy needed to vaporise the water.

(e) (State and explain the effect, if any, on the calculated enthalpy change, ΔH , if

(i) a copper calorimeter were used instead of the polystyrene cup. (2)

The value will be less exothermic because copper calorimeter will absorb more heat energy than polystyrene cup. ~~has higher specific heat capacity will~~

Temperature rise will be lower and hence calculated energy transferred will be lower.

(ii) 3.50 g of damp magnesium carbonate were used. ^{→ less than 3.5g} (2)

The value will be more exothermic because the actual mass of magnesium carbonate is less than 3.5g.



ResultsPlus Examiner Comments

The answer to (i) is clear and correct. However, despite realising that the mass of magnesium carbonate would be less than 3.5g the candidate has come to the wrong conclusion about the enthalpy change.



ResultsPlus Examiner Tip

If you are describing a reaction which becomes more exothermic, say that the enthalpy change is more negative. If it is less exothermic say that it is less negative, rather than more positive which implies an endothermic change.

(e) State and explain the effect, if any, on the calculated enthalpy change, ΔH , if

(i) a copper calorimeter were used instead of the polystyrene cup.

(2)

ΔH would be less exothermic (the value of ΔH would be smaller) as the heat would be lost \Rightarrow the energy ΔT would be smaller \Rightarrow energy transferred would be lower $\Rightarrow \Delta H$ would also be lower

(ii) 3.50 g of damp magnesium carbonate were used.

(2)

no effect on ΔH , it has an effect on the reaction rate but not on ΔH



ResultsPlus Examiner Comments

The answer to (i) is clear enough for both marks, but (ii) is incorrect.

(e) State and explain the effect, if any, on the calculated enthalpy change, ΔH , if

(i) a copper calorimeter were used instead of the polystyrene cup.

(2)

As polystyrene is better at insulation, so the value of ΔH will be ~~larger~~ smaller when use a copper calorimeter the temperature change will be smaller, so ~~the~~ ΔH will be bigger as there is a "-" in the value of ΔH .

(ii) 3.50 g of damp magnesium carbonate were used.

(2)

~~of~~ Damp means with some water, so the volume of the $MgCO_3$ is ~~actually~~ ^{mass} decreases, so the energy transferred will decrease the solution will change so as the mass and energy transfer so the ΔH will increase as there is a "-" in ΔH .
~~so Energy transferred will increase so the ΔH will be~~



ResultsPlus Examiner Comments

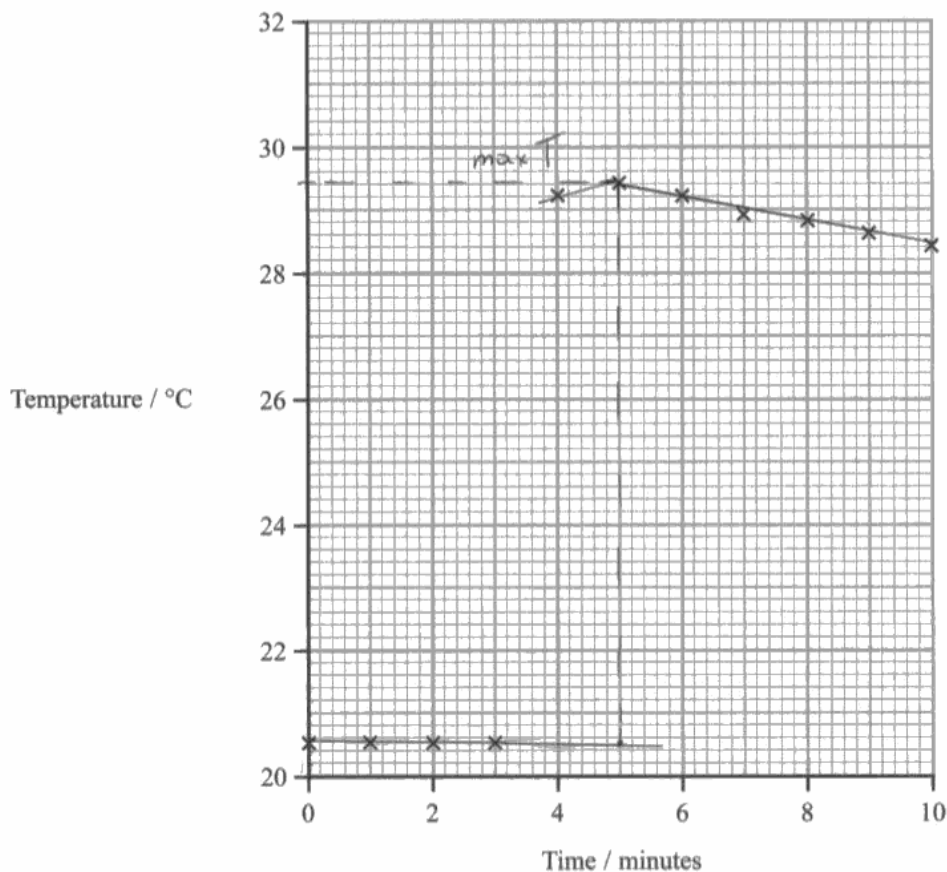
It is true that the temperature change will be smaller in (i) as copper is less good at insulating than polystyrene. For clarity, the answer should have referred to the enthalpy change being less negative, or said that the size of the enthalpy change is smaller.

The reason given for the effect of using damp magnesium carbonate in (ii) is correct.

Question 3 (f)

A large number of candidates did not understand the point of using the changed procedure for the experiment. The most common way of calculating the temperature change was to draw a diagonal line from the point at 3 minutes up to the highest point shown at 5 minutes. Some candidates omitted the horizontal line through the first four points, which are the readings used to check that the solution is in equilibrium with its surroundings and neither heating up nor cooling down. Candidates who drew a vertical line to intersect with the line showing cooling often drew it at 3 or 4 minutes, not 3.5, which is the time when the magnesium carbonate was added.

It was very common to say that this method gives a lot of results so an average can be taken, or that it shows anomalous results. Only a small proportion understood that extrapolating the cooling line back to the time when the magnesium carbonate was added allows a correction to be made for cooling.



- (i) Use this graph to calculate the maximum temperature change. Show your working on the graph.

(2)

Maximum temperature change = 8.8 °C

- (ii) Why does this method give a more accurate result than the original procedure?

(1)

During the original procedure some rough or incorrect measurements may occur that give rough results and in this method the temperature is measured over a period of time



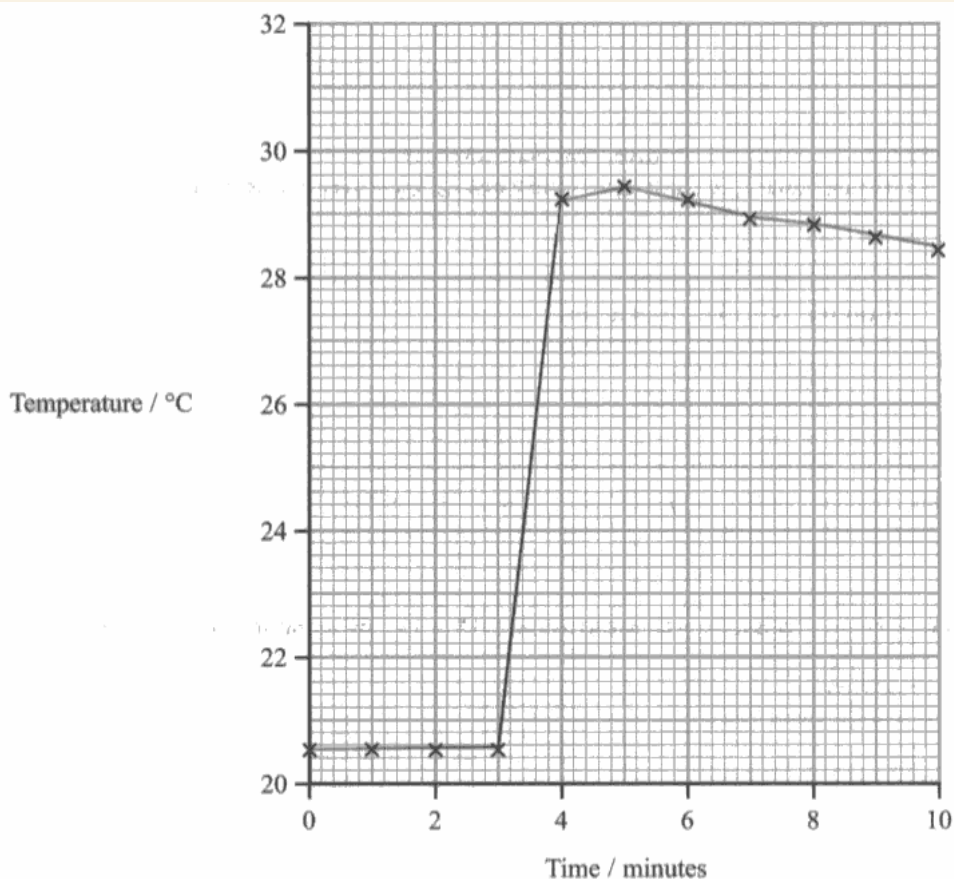
ResultsPlus Examiner Comments

This scored no marks. The cooling curve is only extrapolated back to 4 minutes and the temperature change is not measured at 3.5 minutes.



ResultsPlus Examiner Tip

This method allows us to calculate what the temperature rise would have been when the magnesium carbonate is added, and corrects for loss of heat during cooling. The vertical line should be drawn at the time the magnesium carbonate is added, and the graph showing the temperatures of the cooling mixture extrapolated back to intersect it.



- (i) Use this graph to calculate the maximum temperature change. Show your working on the graph.

(2)

Maximum temperature change = 8.7 °C

- (ii) Why does this method give a more accurate result than the original procedure?

(1)

The graph shows temperature ^{for} each minute and ~~it shows~~ ^{an} anomaly can be spotted. From a graph so it can be ignored in calculations to get ^{a more} accurate result.



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Examiner Comments

The errors shown here were seen very frequently and show that the reasons for using this method are not understood.

Question 4 (a) (b)

Observations were required in (a) so comments such as "hydrogen forms" were not allowed. Some candidates described the same observation in two ways e.g. bubbles and effervescence, and only one of these was allowed.

There are many possible measurements from which rate could be determined, but answers were often unspecific. It was not enough to say that time could be measured unless it was time for all the sodium to dissolve, or time for a certain volume of gas to form. Similarly if a volume of gas was to be measured it had to be at a certain time. Time for reaction to finish was not enough as it did not tie in with any observation, but time for all the sodium to dissolve was allowed. Saying "the rate at which sodium dissolves" does not indicate the measurement which must be taken. It would not be practical to count the number of bubbles produced per minute to measure the rate.

4 This question is about the alcohol, propan-1-ol.

(a) Give **two** observations when propan-1-ol reacts with a small piece of sodium. (2)

Observation 1 Effervescence.

Observation 2 Colourless gas produced.

(b) A student investigated the rate of reaction of propan-1-ol with sodium.

Suggest **one** suitable measurement which could be made to determine the rate of this reaction. (1)

Measuring the amount of gas collected.



ResultsPlus Examiner Comments

Stating that a gas forms, or naming the products of the reaction are not observations and do not gain any marks.



ResultsPlus Examiner Tip

The way to tell that a colourless gas is forming is to see bubbles, so the second observation here is an inference.

Measuring an amount of gas will not determine rate unless it is done at a known time.

4 This question is about the alcohol, propan-1-ol.

(a) Give **two** observations when propan-1-ol reacts with a small piece of sodium.

(2)

Observation 1 *Effervescence occurs.*

Observation 2 *so sodium metal disappears. , white solid formed.*

(b) A student investigated the rate of reaction of propan-1-ol with sodium.

Suggest **one** suitable measurement which could be made to determine the rate of this reaction.

(1)

mass of sodium metal.



ResultsPlus Examiner Comments

Three correct observations are given here. Two were enough for the marks.



ResultsPlus Examiner Tip

Even if the answer to (b) had been "find the mass of sodium metal at different times" it would not have scored a mark. This method of measuring rate is not possible in practice, as the sodium would have to be removed at intervals to weigh it and this would stop the reaction!

Question 4 (c)

Fumes of hydrogen chloride are produced when phosphorus(v) chloride reacts with an alcohol. They are steamy or misty. The description of them as white was allowed.

In (ii) ammonium chloride forms as a white smoke made of solid particles. Many candidates lost this mark as they were unaware of the difference between fumes and smoke.

(c) A small amount of phosphorus(V) chloride (phosphorus pentachloride), PCl_5 , is added to propan-1-ol in a test tube.

(i) Describe the appearance of the fumes at the mouth of the test tube. (1)

Steamy fumes

(ii) An open bottle of concentrated ammonia is held near the mouth of the tube. Describe what would be seen at the mouth of the test tube. (1)

White smoke forms.



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Examiner Comments

This is correct and sufficient for both marks.

(i) Describe the appearance of the fumes at the mouth of the test tube. (1)

Steamy fumes

(ii) An open bottle of concentrated ammonia is held near the mouth of the tube. Describe what would be seen at the mouth of the test tube. (1)

White fumes could be seen.

(Total for Question 4 = 5 marks)



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Examiner Comments

In (b) white fumes was not allowed for the description of the smoke.



ResultsPlus
Examiner Tip

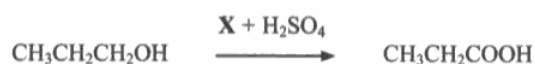
Smoke is made of solid particles which is why ammonium chloride should be described as a smoke, not fumes.

Question 5 (a)

The oxidizing agent which should be mixed with concentrated sulfuric acid in this experiment is potassium or sodium dichromate.

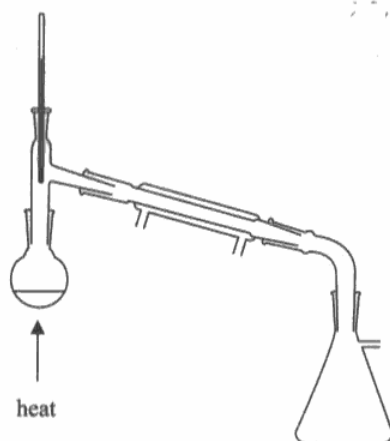
A mixture of solid potassium manganate(VII) and concentrated sulfuric acid would be very hazardous, as it is such a strong oxidizing agent, and it was not allowed.

5 Propanoic acid may be prepared by oxidizing propan-1-ol in acidic conditions.



Procedure

1. Pour 10 cm³ of distilled water into a boiling tube and add 12 g of oxidizing agent X. Shake the mixture and leave X to dissolve.
2. Pour 3 cm³ of propan-1-ol into a round-bottom flask and add 10 cm³ of distilled water and a few anti-bumping granules. Set up the apparatus for heating under reflux.
3. Add 4 cm³ of concentrated sulfuric acid, drop by drop, to the propan-1-ol. While the mixture is still warm, add the solution of oxidizing agent X, drop by drop. The energy released from the reaction should cause the mixture to boil without external heating.
4. When all of the solution of X has been added, use a low Bunsen burner flame to keep the mixture boiling for 10 minutes, not allowing any vapour to escape.
5. Distil the mixture in the flask using the apparatus shown below. Collect 5–6 cm³ of distillate, which is an aqueous solution of propanoic acid.



(a) Suggest, by name or formula, a suitable oxidizing agent, X, for this reaction.

(1)

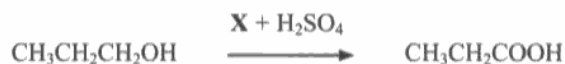
Acidified potassium dichromate (VI)



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Examiner Comments

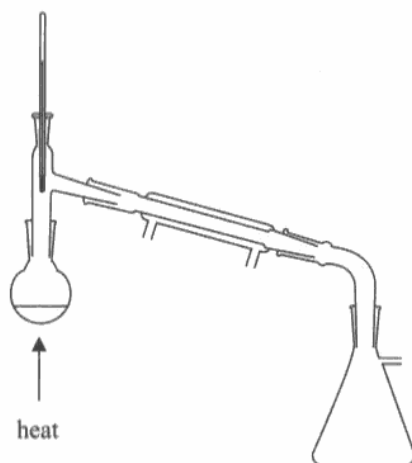
The question refers to using concentrated sulfuric acid, so naming the oxidizing agent was enough without the word "acidified".

5 Propanoic acid may be prepared by oxidizing propan-1-ol in acidic conditions.



Procedure

1. Pour 10 cm³ of distilled water into a boiling tube and add 12 g of oxidizing agent **X**. Shake the mixture and leave **X** to dissolve.
2. Pour 3 cm³ of propan-1-ol into a round-bottom flask and add 10 cm³ of distilled water and a few anti-bumping granules. Set up the apparatus for heating under reflux.
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4. When all of the solution of **X** has been added, use a low Bunsen burner flame to keep the mixture boiling for 10 minutes, not allowing any vapour to escape.
5. Distil the mixture in the flask using the apparatus shown below. Collect 5–6 cm³ of distillate, which is an aqueous solution of propanoic acid.



(a) Suggest, by name or formula, a suitable oxidizing agent, **X**, for this reaction.

(1)

$\text{K}_2\text{Cr}_2\text{O}_7$, potassium dichromate (VI)



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Examiner Comments

Either the name or formula could have been given, but if both are given they must both be correct as here. If the oxidation number is included it must also be correct.

Question 5 (b)

The colour change when using potassium dichromate is from orange to green. Some candidates gave this the wrong way round.

(b) What colour change does X undergo when it oxidizes propan-1-ol?

(1)

From *orange* to *green*

yellow



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Examiner Comments

Dichromate ions are not yellow.



ResultsPlus
Examiner Tip

The yellow colour here is incorrect. Chromate ions are yellow, but dichromate ions are orange.

(b) What colour change does X undergo when it oxidizes propan-1-ol?

(1)

From *green* to *orange*



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Examiner Comments

The colours here are the wrong way round.



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Examiner Tip

The order of the colours is important in a question like this. This also applies when you are asked for the colour changes of indicators.

Question 5 (c) (d) (e)

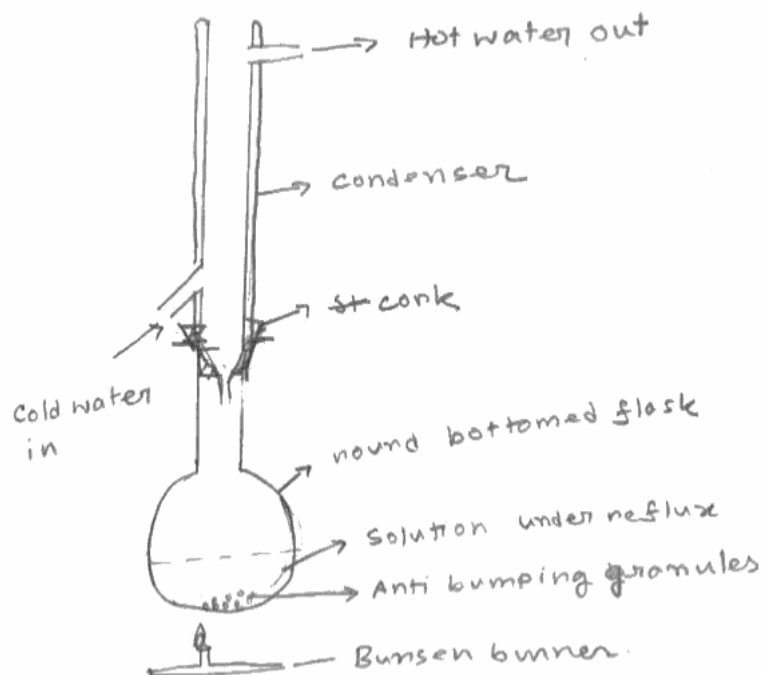
Many candidates knew that heating under reflux meant that the reaction flask was fitted with a condenser in a vertical position. However, the condenser was often shown sealed with a stopper or tap funnel. Some candidates were unsure of the structure of a condenser and showed water entering the inner part rather than the outer jacket, or having the outer jacket open to the flask.

In (d) many suggested a possible hazard of escaping vapour, and also that there would be a loss of yield if reactants or products escaped. Some candidates missed the point and suggested errors which occur in other experiments, such as heat losses or "inaccurate reactions".

Many answers to (e) wrongly suggested that escape of vapour could be prevented by using a stopper.

(c) Draw a **labelled** diagram showing the apparatus for heating under reflux.

(2)



(d) Give **two** reasons why the escape of vapour in step 4 should be prevented.

(2)

Reason 1 So that the ^{vapour} mixture does not evaporate gas escapes to the surrounding and less yield of acid is collected

Reason 2 So the hot gases does not heat under the condenser

(e) How does the reflux apparatus prevent escape of vapour?

(1)

⊖ The unwanted vapour with lower boiling point escapes while the acid vapour with higher boiling point is condensed by the condenser



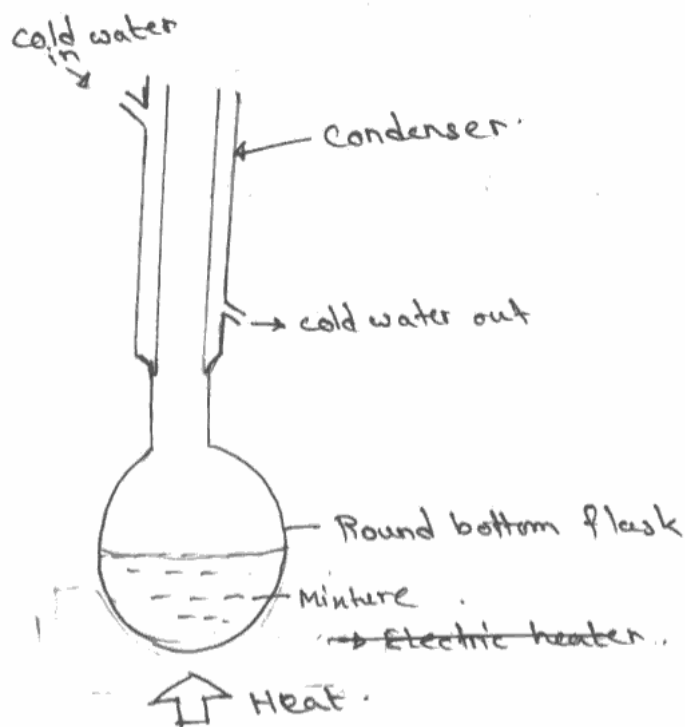
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Examiner Comments

The cooling water here is going in to the centre of the condenser.

The second reason given in (d) is incorrect.

In (e) the mark was not given as though it is correct to say that vapour would condense, it is incorrect to say that unwanted vapour escapes. The lower boiling point vapour would be the aldehyde or alcohol.

(2)



(d) Give **two** reasons why the escape of vapour in step 4 should be prevented.

(2)

Reason 1 Escape of vapour will decrease
the yield.

Reason 2 Rate of reaction will also decrease.

(e) How does the reflux apparatus prevent escape of vapour?

(1)

It condenses the ^{vapours} volatile substances and
causes it to run back to the flask.



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Examiner Comments

This candidate does not know the structure of a condenser and has left the outer jacket open at the top.

The comment in (d) on rate of reaction is incorrect, but (e) shows understanding of how the condenser works.

Question 5 (f)

Many candidates could suggest a suitable drying agent. However calcium oxide, which was often suggested, would react with the propanoic acid. Calcium carbonate was another incorrect suggestion which appeared regularly.

Answers to (ii) frequently referred to the drying agent absorbing the produce or coming through the filter paper and did not make it clear that filter paper would absorb some of the liquid product.

(f) Some water can be removed from the distillate in step 5 by adding a solid drying agent. The solution of propanoic acid can then be decanted leaving the drying agent behind.

(i) Suggest a suitable solid drying agent.

(1)

Anhydrous calcium chloride.

(ii) Suggest why removing excess solid drying agent by decanting, rather than filtering through filter paper, improves the yield.

(1)

Because the filter paper absorbs the propanoic acid ^{if it is} by filtering ^{red} through it.



ResultsPlus
Examiner Comments

The meaning here is clear.

(f) Some water can be removed from the distillate in step 5 by adding a solid drying agent. The solution of propanoic acid can then be decanted leaving the drying agent behind.

(i) Suggest a suitable solid drying agent.

(1)

Anhydrous calcium chloride.

(ii) Suggest why removing excess solid drying agent by decanting, rather than filtering through filter paper, improves the yield.

(1)

The decanting process is faster where the ~~the~~ solution is removed quickly, leaving the solid behind. ~~The~~ Filtering through filter paper is a very slow process which may cause some of the ~~the~~ product to be left behind in the filter paper or vapourize before being collected.



ResultsPlus

Examiner Comments

Three answers have been given here, of which two are incorrect and one unclear. The decanting process is faster than filtering, but this is not why the yield is improved. The propanoic acid is unlikely to vaporise during filtration. Saying that the product may be left behind in the filter paper and solid does not make it clear that the liquid product is absorbed by the paper.



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Examiner Tip

Don't give several reasons in an answer unless more than one is asked for.

Question 5 (g)

The calculations in both parts were well done. Most candidates correctly calculated the number of moles of propanol used and hence the mass of propanoic acid. Various methods were possible to find the percentage yield. The most popular was to find the mass of 6.0cm³ of propanoic acid first, but quite a few candidates found the volume of the propanoic acid which they had calculated in (i), and then found the yield by comparison of the actual and theoretical volumes. A few found the number of moles in 6.0cm³ propanoic acid, and worked from there. If the mass of propanoic acid was calculated incorrectly in (i) then the error was allowed to be carried forward to calculate the percentage yield.

The main errors were from the candidates who did not know the relationship of density, mass and volume. There were also regular examples of incorrect rounding of values.

- (i) Calculate the maximum mass of propanoic acid which could be formed from 10.0 g of propan-1-ol.

	Propan-1-ol	Propanoic acid
Molar mass / g mol ⁻¹	60.1	74.1

(2)

$$\frac{10\text{g}}{60.1} = 0.166 \text{ mol of propan-1-ol}$$

hence 0.166 mol of propanoic acid form if 100% yield.

$$0.166 \times 74.1 = \underline{\underline{12.32\text{g}}}$$

(ii) After purification, 6.0 cm^3 of dry propanoic acid was obtained.

Calculate the percentage yield in the preparation.

The density of propanoic acid is 0.99 g cm^{-3} .

$$\begin{aligned} \text{mass of propanoic acid} &= 0.99 \times 6.0 \text{ cm}^3 \\ &= 5.94 \text{ g} \end{aligned}$$

$$\rho = \frac{m}{V}$$

(2)

$$\frac{5.94}{12.32} \times 100\% = 48.2\%$$

$$\frac{5.94}{0.166 \times 74.1} \times 100\%$$

$$= \frac{5.94}{12.32} \times 100\%$$

$$= \underline{48.2\%}$$

(h) In another experiment, the same reaction mixture (propan-1-ol, X and concentrated



ResultsPlus Examiner Comments

This is an example of one of the many rounding errors seen in this paper.



ResultsPlus Examiner Tip

Be careful when rounding the figures you give in your answer.

The mass here should be 12.33 if two decimal places are given.

- (i) Calculate the maximum mass of propanoic acid which could be formed from 10.0 g of propan-1-ol.

	Propan-1-ol	Propanoic acid
Molar mass / g mol ⁻¹	60.1	74.1

$$\text{mol of propan-1-ol} = \frac{10}{60.1} = 0.17 \text{ mol}$$

since ratio is 1:1, mol of propanoic acid = 0.17 mol.

$$\begin{aligned} \text{maximum mass} &= 0.17 \times 74.1 \\ &= 12.6 \text{ g} \end{aligned}$$

(2)

- (ii) After purification, 6.0 cm³ of dry propanoic acid was obtained.

Calculate the percentage yield in the preparation.

The density of propanoic acid is 0.99 g cm⁻³.

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

$$\text{percentage yield} = \frac{6 \times 0.99}{12.6} \times 100 = 47.1 \%$$

(2)



ResultsPlus Examiner Comments

This candidate has rounded the number of moles to two significant figures and then calculated the mass of propanoic acid to three figures. As the method was correct this was allowed, but it shows that early rounding can make a percentage difference in the answer of over 2%.

The answer to the second part follows from the answer to the first and gained both marks even though the step to calculate the volume was not shown separately.



ResultsPlus Examiner Tip

If there are two steps in a calculation it is a good idea to show the calculation method for the first, in case you make an error with the arithmetic in the final answer.

Question 5 (h)

Many candidates knew that an aldehyde would form if the distillation apparatus was used, but did not specify the name of the actual product.

The reason why a different product would form was not well understood. Some candidates said that refluxing produced an acid and distilling produced an aldehyde without explaining why. Candidates who said that distillation prevented complete oxidation occurring were allowed the mark, but the best answers said that the aldehyde would distil off as it formed, making further oxidation impossible.

(h) In another experiment, the same reaction mixture (propan-1-ol, X and concentrated sulfuric acid) was heated in the apparatus shown in step 5. Identify the main organic product which would be collected and explain why propanoic acid is not produced.

(2)

Product..... propanal

Explanation..... Because propanal oxidizes ~~not~~ before propanoic acid as a result the first 5-6cm³ of distillate wont have propanoic acid

(Total for Question 5 = 15 marks)

alcohol → aldehyde - carboxylic acid TOTAL FOR PAPER = 50 MARKS



ResultsPlus Examiner Comments

The explanation is too confused for credit. Propanal is the first oxidation product of propanol, and if propanoic acid formed it would not oxidize further. It is true that propanoic acid would not distil over in the apparatus in step 5, but the answer implies that some might be produced after the first few cm³.



ResultsPlus Examiner Tip

Learn why different apparatus is used to obtain different oxidation products, not just that refluxing produces the carboxylic acid.

(h) In another experiment, the same reaction mixture (propan-1-ol, X and concentrated sulfuric acid) was heated in the apparatus shown in step 5. Identify the main organic product which would be collected and explain why propanoic acid is not produced.

(2)

Product *propanal*

Explanation *Because propanal has a lower boiling point than propanoic acid and propanal is distilled off before it can be further oxidized to propanoic acid*

(Total for Question 5 = 15 marks)



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Examiner Comments

This is an example of a good answer.

Paper Summary

Many candidates either do not know or do not understand why experiments are done in a particular way. It is valuable to think about why experiments are carried out in a certain way, and not just follow the instructions without considering the chemistry involved.

It is important to read the question carefully, take care with significant figures, and practice drawing clear, correct diagrams of basic apparatus used in AS chemistry.

The Edexcel User Guide gives results of the analytical tests which are in the specification, and should be used for guidance when describing colours.

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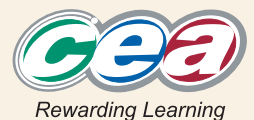
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