Pearson
Edexcel

Examiners' Report
June 2024

IAL Chemistry WCH13 01

ResultsPlus

Introduction

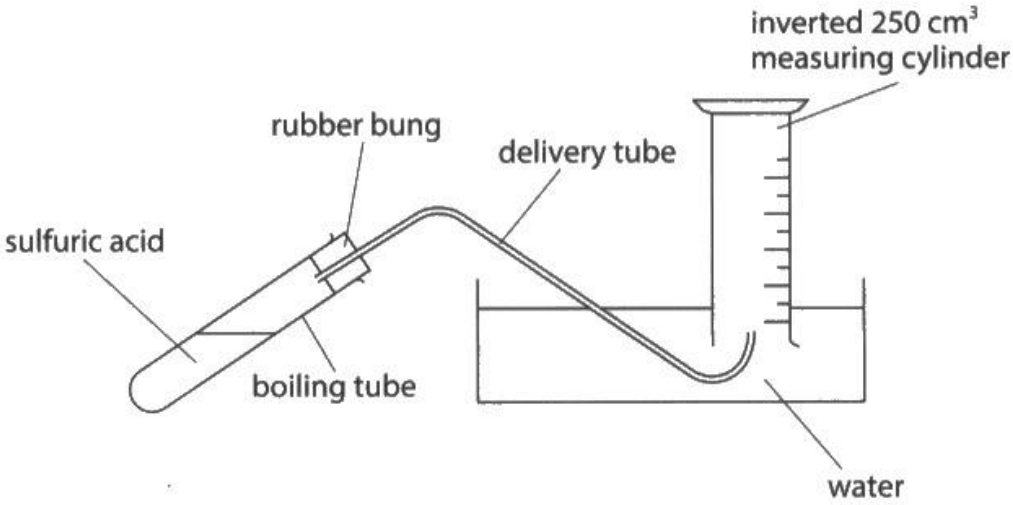
This practical skills paper gives candidates the opportunity to demonstrate their knowledge and understanding of experimental procedures and techniques. There was evidence that many candidates had prepared well and gave answers which showed that they could apply their chemical knowledge and understanding. However, it was also true that a significant proportion of candidates could not demonstrate a clear understanding of some fundamental chemical principals. There was no evidence that candidates ran out of time, but there was considerable evidence of their inability to answer questions effectively.

Question 1 (a)

This opening question was a straightforward molar gas calculation which helped the candidates to 'settle in' to the paper. Many fully correct answers were seen but a significant minority missed the reference to sulfuric acid being "an excess" and so used the wrong number of moles. Candidates are expected to note key information given in the text and also to have some understanding of the numbers that they are calculating. Hence it was surprising that the candidates using the moles of acid and determining a numerical value for the molar volume of gas to be 2.4, didn't realise that they must have made a mistake given that the standard molar volume of a gas is ten times larger. However, transferred error was applied so that these candidates were not overly penalised as shown by the following example.

1 This is a question about practical activities involving the collection of a gas.

(a) A student used the apparatus shown to collect the gas produced from the reaction between copper(II) carbonate and sulfuric acid.



The bung was removed and 0.650 g of copper(II) carbonate was added to 25.0 cm^3 of 2.00 mol dm^{-3} sulfuric acid (an excess) in the boiling tube.
The bung was quickly replaced and 120 cm^3 of carbon dioxide gas was collected in the measuring cylinder.
The equation for the reaction is shown.

$$CuCO_3(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l) + CO_2(g)$$

Calculate the molar volume of carbon dioxide gas, in $dm^3\,mol^{-1}$, from these data.
Give your answer to an appropriate number of significant figures.

(3)

$n(CuCO_3) = \dfrac{0.650}{(63.5+12+(3\times16))}$

$= 5.26\times10^{-3}$ mol

$= n(CO_2) = 5.26\times10^{-3}$ mol

molar volume of $CO_2 = \dfrac{(120\div1000)}{5.26\times10^{-3}}$

$= 22.8$

$= 23\ dm^3\ mol^{-1}$

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

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

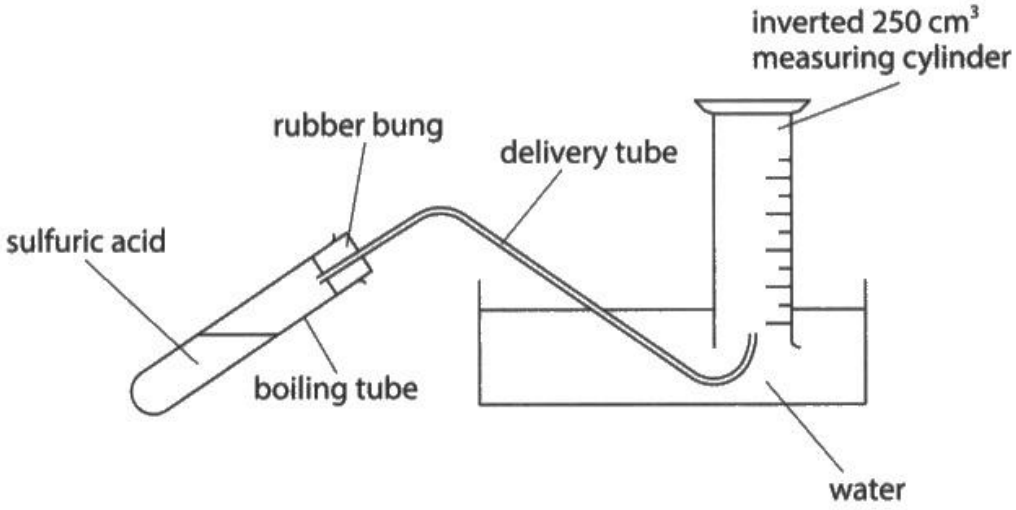
This is an example of a response which scores all 3 marks.

The layout is clear and the final answer is given to 2 significant figures.

Remember that the final answer is the one marked and so make sure that it is to the degree of accuracy that is required.

1 This is a question about practical activities involving the collection of a gas.

(a) A student used the apparatus shown to collect the gas produced from the reaction between copper(II) carbonate and sulfuric acid.



The bung was removed and 0.650 g of copper(II) carbonate was added to 25.0 cm^3 of 2.00 mol dm^{-3} sulfuric acid (an excess) in the boiling tube.
The bung was quickly replaced and 120 cm^3 of carbon dioxide gas was collected in the measuring cylinder.
The equation for the reaction is shown.

$$CuCO_3(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l) + CO_2(g)$$

Calculate the molar volume of carbon dioxide gas, in $dm^3\,mol^{-1}$, from these data.
Give your answer to an appropriate number of significant figures.

(3)

$2.00 \times \frac{25}{1000} = 0.05$

$0.05 \div \frac{120}{1000} \neq 0.416$

~~0.416 dm³~~

~~0.05~~

$\frac{120}{1000} \div 0.05 = 2.4\ dm^3\ mol^{-1}$

ResultsPlus
Examiner Comments

This is an example of a response which scored 2 marks.

The first marking point is not awarded because the number of moles is of the acid and not the carbonate. However, transferred error is applied and the subsequent calculations steps are correct which means that marking points 2 and 3 are awarded.

ResultsPlus
Examiner Tip

Take note of the passage of text before a question because there may be relevant information that applies, such as that an acid is in "excess".

Question 1 (b)(i)

The greater number of candidates correctly gave the observation when an acid reacts with sodium hydrogen carbonate which was pleasing to see.

(b) After the reaction, tests can be carried out on the mixture to show that the sulfuric acid was in excess.

(i) State the observation if a small volume of sodium hydrogencarbonate solution was added to show that the acid was in excess.

(1)

$NaHCO_3$, forms effervescence of CO_2 gas and bubbles of H_2 gas

ResultsPlus
Examiner Comments

Here is an illustration of an answer that includes two answers, the first being correct but is then followed by an incorrect one.

The gas given off is carbon dioxide and not hydrogen. An incorrect observation or comment is penalised and no mark was awarded.

ResultsPlus
Examiner Tip

Avoid giving two different answers to one question because one may negate the other.

(b) After the reaction, tests can be carried out on the mixture to show that the sulfuric acid was in excess.

(i) State the observation if a small volume of sodium hydrogencarbonate solution was added to show that the acid was in excess. Na2CO3

(1)

lime water will turn milky

ResultsPlus
Examiner Comments

No mark was given for a secondary test.

In order to gain the mark, there needed to be reference to the observation of bubbles or fizzing or effervescence and since this is absent in this response, no mark is awarded.

(b) After the reaction, tests can be carried out on the mixture to show that the sulfuric acid was in excess.

(i) State the observation if a small volume of sodium hydrogencarbonate solution was added to show that the acid was in excess.

(1)

Carbon dioxide gas will be given off.

ResultsPlus
Examiner Comments

A gas

ResultsPlus
Examiner Tip

Remember that an observation is normally something that can be seen.

Question 1 (b)(ii)

This should have been a very accessible two marks, but a sizeable number of candidates failed to understand what was required. The question clearly stated that a 'different' (in bold font) test for an acid in excess was required. However, many answers describing the use of barium chloride to show the presence of sulfate ions were given. These ions will be present in excess sulfuric acid, but the question referred to 'acid' in general.

Some candidates demonstrated their recall of the oxidation of halide ions by concentrated sulfuric acid and so suggested this as a test. This is not a suitable test on the reaction mixture which was stated in the question. In a similar vein, a good number of candidates suggested the use of an indicator which was allowed to score 1 mark only because the reaction mixture contained blue copper(II) sulfate that would mask any indicator colour change. The use of the indicator phenolphthalein was seen but did not score because it is colourless before use and remains colourless in excess acid.

It would be good for candidates to remember the context or the situation of a particular test which will help to decide on its suitability.

(ii) Describe a **different** test, and the positive observation, that could be carried out to show that the acid was in excess.

(2)

use a drop of methyl orange, the color turns red.

$H_2SO_4 + CuCl_2 \rightarrow CaSO_4 + 2HCl$

Phenol

ResultsPlus
Examiner Comments

This is an example of a response which scored 1 mark.

ResultsPlus
Examiner Tip

Try to visualise what the apparatus might look like and how further activities could be carried out.

(ii) Describe a **different** test, and the positive observation, that could be carried out to show that the acid was in excess.

(2)

Add excess copper (II) carbonate and see if the reaction continues by checking if the volume of CO_2 produced increases.

ResultsPlus
Examiner Comments

This response did not score because the addition of a carbonate is not a different test to the addition of a hydrogencarbonate.

ResultsPlus
Examiner Tip

If a word or expression is in bold font, it requires specific attention.

(ii) Describe a **different** test, and the positive observation, that could be carried out to show that the acid was in excess.

(2)

~~Add $NaHCO_3$ & ~~NO~~ Na_2CO_3 to the sulfuric acid~~

Add ~~dil~~ diluted nitric acid and $BaCl_2$ to the Sulfuric acid and you can observe a white precipitate of $BaSO_4$

H_2SO_4

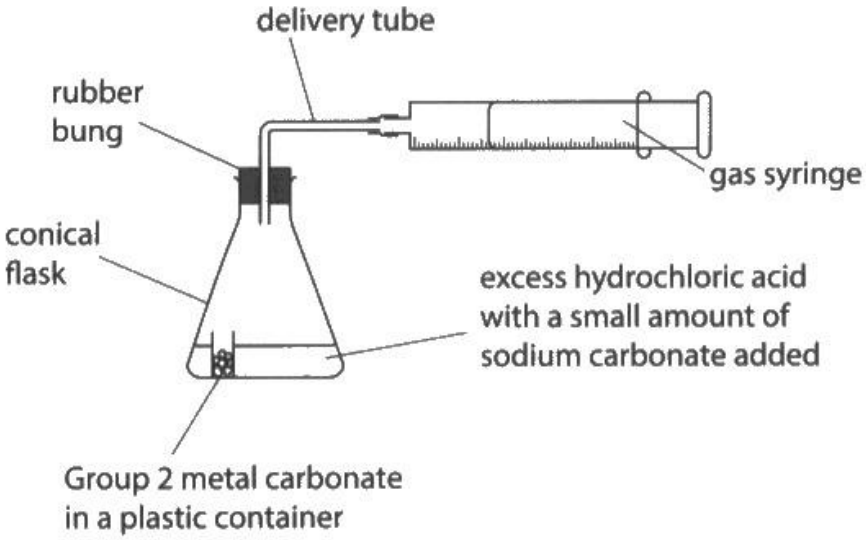
ResultsPlus
Examiner Comments

Here is an example of a response which was often seen that is testing for the presence of sulfate ions rather than the protons or hydrogen ions.

Question 1 (c)(i)

Over recent years, both of the sets of apparatus have been employed and so this question enabled them to be compared. Some candidates vaguely referred to the use of the second set and how it would mean 'no gas was lost', but without any justification. There had to be specific reference to the bung needing to be replaced in the first set of apparatus for this mark to be awarded. The diagram of the gas syringe had more divisions than the measuring cylinder, so this was accepted as a comparison although in practice it is doubtful if this is true in reality.

(c) Another student used the apparatus shown to collect the volume of gas produced from the reaction between a Group 2 metal carbonate and excess hydrochloric acid.



(i) Give **two** reasons why the second set of apparatus gives a more accurate measurement of the volume of gas given off.
Justify your answers.

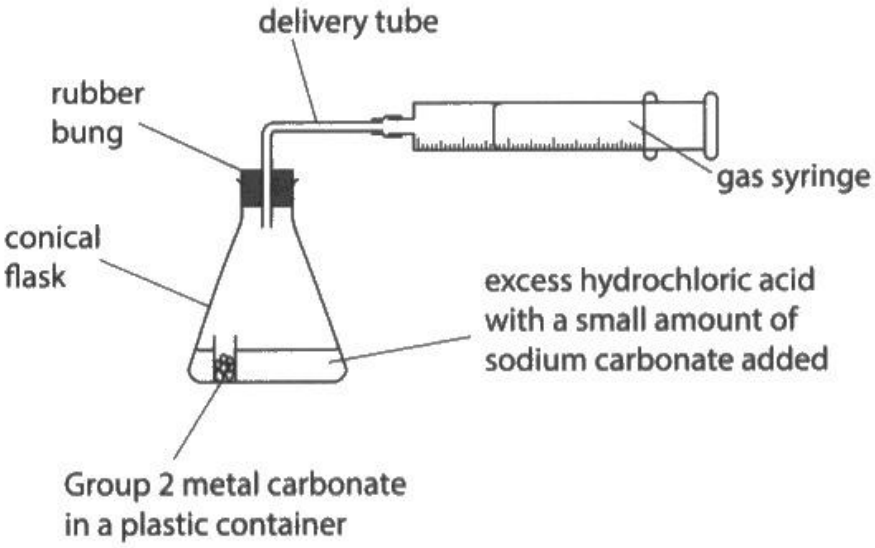
(2)

Gas syringe has smaller measurement ↓ intervals so reading will be more accurate, and ~~gas~~ CO_2 can escape or dissolve in the water with the inverted measuring cylinder.

ResultsPlus
Examiner Comments

In this response, there are two acceptable reasons given for the greater accuracy of the second set of apparatus and so scores 2 marks.

(c) Another student used the apparatus shown to collect the volume of gas produced from the reaction between a Group 2 metal carbonate and excess hydrochloric acid.



(i) Give **two** reasons why the second set of apparatus gives a more accurate measurement of the volume of gas given off.
Justify your answers.

(2)

- using gas syringe is more accurate, and conical flask reduces heat lost to surrounding.

ResultsPlus
Examiner Comments

It is insufficient to just state a piece of equipment is more accurate, there needs to be an accompanying reason or justification given. The second suggestion is not relevant to the question asked and so this response scores zero.

ResultsPlus
Examiner Tip

Note that the end of the question states "Justify your answers" and so this must be done for marks to be awarded.

Question 1 (c)(ii)

The majority of candidates correctly determined the Group 2 metal to be magnesium. Unfortunately, some candidates forgot the Group 2 requirement and went with the element that had the nearest relative atomic mass, namely aluminium. A reminder to always re-read the question to ensure that the answer given does match the question.

(ii) The reaction of 0.320 g of the Group 2 metal carbonate resulted in 89.0 cm^3 of carbon dioxide gas being collected in the gas syringe.

$$MCO_3(s) + 2HCl(aq) \rightarrow MCl_2(aq) + H_2O(l) + CO_2(g)$$

Determine, by calculation, the identity of the Group 2 metal from these data.
You **must** show your working.
Assume a molar gas volume of 24 000 $cm^3\,mol^{-1}$.

(3)

Moles of $CO_2 = 89 \div 24000 = 0.003708$ mol
Mole ratio of $MCO_3 : CO_2 = 1:1$
∴ Moles of $MCO_3 = 0.003708$ mol
~~Molar~~ ~~Molecular~~ mass of $MCO_3 = 0.320 \div 0.003708$
$= 86.3\ g\,mol^{-1}$
Molar mass of $M = 86.3 - (12 + 16 \times 3) = 26.3\ g\,mol^{-1} \approx 24.3\ g\,mol^{-1}$
∴ The metal is Mg, magnesium

ResultsPlus
Examiner Comments

A fully correct response which is clearly laid out and scored all 3 marks.

ResultsPlus
Examiner Tip

A clear layout of working will help the examiner to understand what is being done and will help you to organise your actions properly.

(ii) The reaction of 0.320 g of the Group 2 metal carbonate resulted in 89.0 cm^3 of carbon dioxide gas being collected in the gas syringe.

$$MCO_3(s) + 2HCl(aq) \rightarrow MCl_2(aq) + H_2O(l) + CO_2(g)$$

Determine, by calculation, the identity of the Group 2 metal from these data.
You **must** show your working.
Assume a molar gas volume of 24000 $cm^3\,mol^{-1}$.

(3)

$n \text{ of } CO_2 = \frac{V}{24000} = \frac{89}{24000} = 3.7083 \times 10^{-3}$

$CO_2 : MCO_3$
$1 : 1$

$n = \frac{m}{Mr} \quad Mr = \frac{m}{n} = \frac{0.320}{3.7083 \times 10^{-3}} = 86.29 \text{ g/mol}$

$\downarrow$
Sr

$= SrCO_3$

ResultsPlus
Examiner Comments

This response scored 2 marks and not all 3 because there is no subtraction of the 'carbonate' from the compound to identify the Group 2 metal.

This candidate has written the formula of the Group 2 metal carbonate but failed to realise that the molar mass calculated is of the whole compound and not just the Group 2 metal.

ResultsPlus
Examiner Tip

Make sure that any moles that are calculated are clearly labelled with the compound and then this will help to determine how the value should then be used.

Question 2 (a)

It was expected that this would be an easily accessible mark and so it is disappointing that only about half of the candidates were awarded the mark. A number of similar questions have been asked in the past and so it is a surprise that this was found so challenging. Some candidates referred to the volatility of bromoethane, but this question was about Step 2 which only had ethanol and sulfuric acid present. Hence another reminder to carefully note whereabouts in the procedure the question relates to.

2 Bromoethane was prepared from the reaction of ethanol with sulfuric acid and potassium bromide.

$$C_2H_5OH + H_2SO_4 + KBr \rightarrow C_2H_5Br + KHSO_4 + H_2O$$

Procedure

Step **1** 10.0 cm^3 of ethanol was placed in a round-bottomed flask.

Step **2** 10.0 cm^3 of concentrated sulfuric acid was added carefully and gradually to the ethanol in the flask.

Step **3** 12.0 g of potassium bromide was added to the reaction mixture in the flask.

Step **4** The flask was set up for distillation and heated gently.

Step **5** Water, ethanol and bromoethane were collected in a small beaker.

Step **6** The bromoethane was purified.

Step **7** The bromoethane was dried.

(a) Suggest why the flask in Step **2** was frequently placed in a stream of cold running water as the sulfuric acid was gradually added.

(1)

AS the reaction is exothermic if not cooled combust the ethanol will ~~combust~~ as it is highly flammable.

ResultsPlus
Examiner Comments

This response was not awarded the mark because although the initial comment is creditworthy, the candidate has then stated that the ethanol will combust which is incorrect. Hence this negates the correct opening statement.

ResultsPlus
Examiner Tip

Avoid writing excessively because a correct point can be undone by an incorrect one.

2 Bromoethane was prepared from the reaction of ethanol with sulfuric acid and potassium bromide.

$$C_2H_5OH + H_2SO_4 + KBr \rightarrow C_2H_5Br + KHSO_4 + H_2O$$

Procedure

Step **1** 10.0 cm^3 of ethanol was placed in a round-bottomed flask.

Step **2** 10.0 cm^3 of concentrated sulfuric acid was added carefully and gradually to the ethanol in the flask.

Step **3** 12.0 g of potassium bromide was added to the reaction mixture in the flask.

Step **4** The flask was set up for distillation and heated gently.

Step **5** Water, ethanol and bromoethane were collected in a small beaker.

Step **6** The bromoethane was purified.

Step **7** The bromoethane was dried.

(a) Suggest why the flask in Step **2** was frequently placed in a stream of cold running water as the sulfuric acid was gradually added.

(1)

The reaction is highly exothermic ~~This is to form~~

ResultsPlus
Examiner Comments

This concise response scored the mark for the 'Allow' answer on the mark scheme.

2 Bromoethane was prepared from the reaction of ethanol with sulfuric acid and potassium bromide.

$$C_2H_5OH + H_2SO_4 + KBr \rightarrow C_2H_5Br + KHSO_4 + H_2O$$

Procedure

Step **1** 10.0 cm^3 of ethanol was placed in a round-bottomed flask.

Step **2** 10.0 cm^3 of concentrated sulfuric acid was added carefully and gradually to the ethanol in the flask.

Step **3** 12.0 g of potassium bromide was added to the reaction mixture in the flask.

Step **4** The flask was set up for distillation and heated gently.

Step **5** Water, ethanol and bromoethane were collected in a small beaker.

Step **6** The bromoethane was purified.

Step **7** The bromoethane was dried.

(a) Suggest why the flask in Step **2** was frequently placed in a stream of cold running water as the sulfuric acid was gradually added.

(1)

This is to prevent the concentrated sulfuric acid from fully oxidizing Br^- in KBr to form Br_2 (g), which cannot form bromoethane.

ResultsPlus
Examiner Comments

This is an example of a response which has referred to a different step in the procedure to that being asked. Only ethanol and sulfuric acid are present in the flask in Step 2. Hence this does not score.

ResultsPlus
Examiner Tip

Take care to make sure that reference is made to the correct step in the procedure.

Question 2 (b)

It would be worthwhile for candidates to practise the correct spelling of laboratory equipment which is commonly used. A significant number of candidates struggled with the spelling of 'pestle and mortar' which occasionally were helped by a drawing.

(b) The potassium bromide used in Step **3** was initially lumpy and not a fine powder. State the apparatus that would be suitable for breaking up the lumps of potassium bromide into a powder.

(1)

Use a grinder and thistle.

ResultsPlus
Examiner Comments

This is an example of an incorrect spelling of 'pestle and mortar' and since "thistle" is a plant which is clearly incorrect, no mark was awarded.

ResultsPlus
Examiner Tip

Learn the correct spellings of laboratory equipment.

(b) The potassium bromide used in Step **3** was initially lumpy and not a fine powder. State the apparatus that would be suitable for breaking up the lumps of potassium bromide into a powder.

(1)

glass rod

ResultsPlus
Examiner Comments

This is an example of a response which did not score.

If a 'receptacle' such as a beaker had been also stated with the glass rod, then the mark could have been awarded.

ResultsPlus
Examiner Tip

Try to picture all of the equipment which will be needed or used when asked to state apparatus.

(b) The potassium bromide used in Step **3** was initially lumpy and not a fine powder. State the apparatus that would be suitable for breaking up the lumps of potassium bromide into a powder.

(1)

motar thond Pistol

ResultsPlus
Examiner Comments

This is an example of a misspelling which can mean something other than that expected. Hence the use of "pistol" was not allowed and this response did not score.

Question 2 (c)

The second mark of this question was purposely designed to be more testing and this proved to be the case. Unfortunately, a large number of candidates also struggled to gain the first mark and demonstrated a poor lack of understanding by suggesting the orange colour was due to the potassium bromide or just the bromide ions or even HBr. No mark was also given for the use of the chemical symbol Br because the orange colour is due to the bromine molecule. Candidates would often gain more marks if they wrote the chemical name out in full rather than just the chemical symbol. Of course, this takes more time but as this example illustrates, it means the difference between the mark being awarded and not.

(c) Explain why an orange colour was seen in the round-bottomed flask when it was first gently heated in Step **4**.

(2)

Br ~~mine~~ fumes released which are orange in color

ResultsPlus
Examiner Comments

The symbol "Br" was not acceptable for bromine and so this does not score.

ResultsPlus
Examiner Tip

Avoid using the chemical symbol as an abbreviation.

(c) Explain why an orange colour was seen in the round-bottomed flask when it was first gently heated in Step **4**.

(2)

Because bromide ion formed for a while which has a cream orange color

ResultsPlus
Examiner Comments

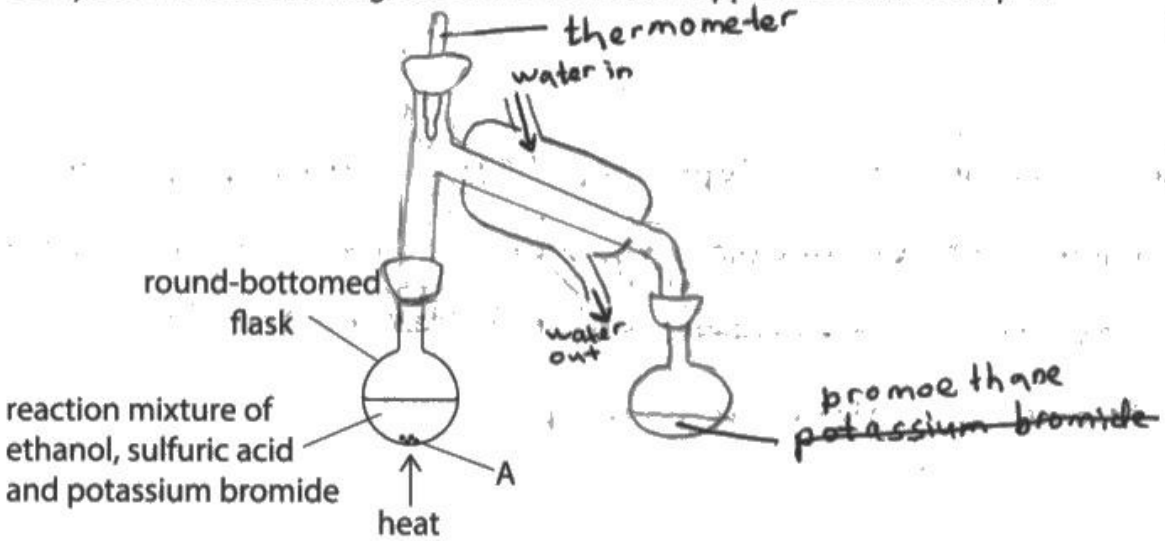
In this response, it is clear that the candidate is stating that the bromide ion is responsible for the orange colour which was a common incorrect answer.

Question 2 (d)

It is strongly recommended that candidates spend time practising the drawing of apparatus set ups like distillation and reflux. In the stress of the exam setting, it can be very hard to do such accurately if someone has not practised beforehand. Examiners had a number of key points that they were looking for, but it was a challenging task. Oftentimes there were gaps in the apparatus where there shouldn't be, a sealed piece of apparatus where it shouldn't be and incomplete labels. The decision was made not to penalise an unclear 'stillhead' in this instance, but this may not always be the case. Candidates and their centres are reminded that these apparatus set ups are made from more than one piece of equipment and so it should not be shown as one continuous piece.

(d) Complete the labelled diagram of the distillation apparatus used in Step **4**.

(3)



ResultsPlus
Examiner Comments

This candidate has drawn a bung at the top of the round-bottomed flask without a hole for the gas to escape. Entry to the condenser is fine and so is the drawing of the condenser 'water jacket'. However, the water in and water out are the wrong way round and there is no safety vent or means for any gas to escape from the end of the condenser.

A collection vessel is drawn, so 3 MS points are given which equates to 1 mark.

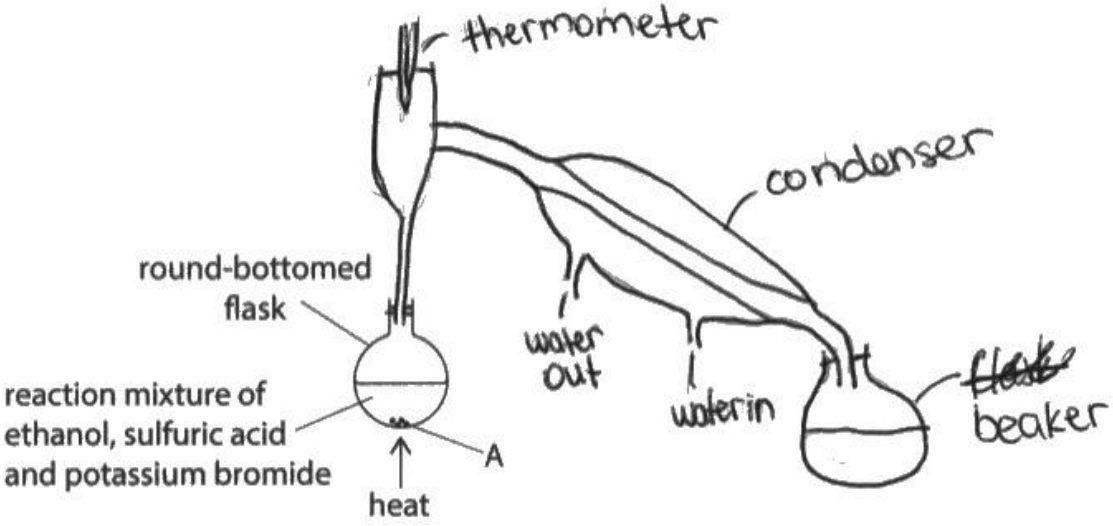
ResultsPlus
Examiner Tip

If a bung/cork is drawn, make sure that a passage or a hole is clearly drawn to allow the movement of gas if that is what is desired.

Remember, the phrase "water in at the bottom and out at the top" for the condenser water flow.

(d) Complete the labelled diagram of the distillation apparatus used in Step **4**.

(3)



ResultsPlus
Examiner Comments

Gas can flow out of the round-bottomed flask, but the entry into the condenser is sealed off. The condenser is drawn ok and the labelling is also. However, there is no vent or way for any gas to escape as there is a line drawn across at the top of the collection vessel.

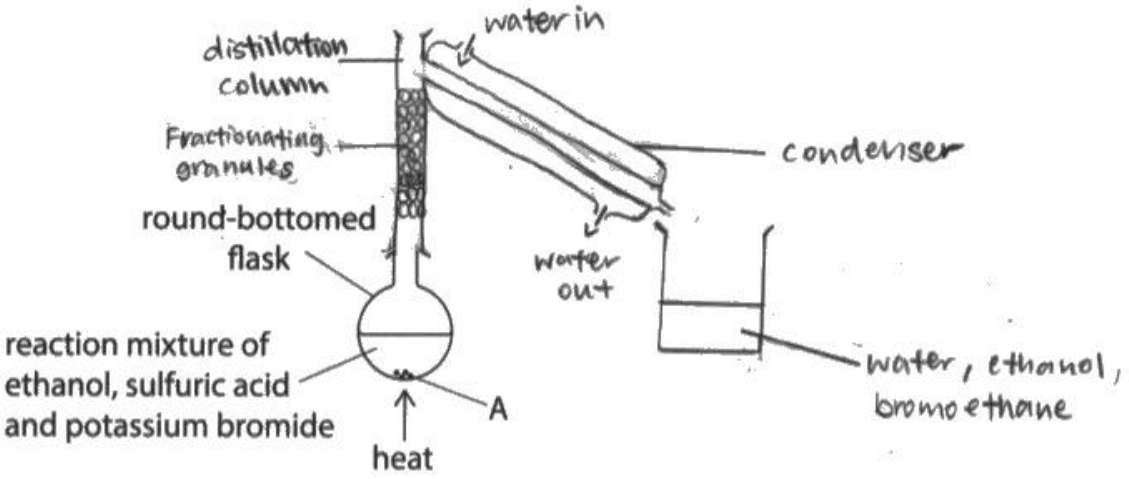
Hence four MS points are made which equates to 2 marks.

ResultsPlus
Examiner Tip

Check that the passage of a gas through the apparatus is clear.

(d) Complete the labelled diagram of the distillation apparatus used in Step **4**.

(3)



ResultsPlus
Examiner Comments

The flow of gas from the round-bottomed flask is fine as the fractionating column granules are ignored, but the top of the column is open which is incorrect. The condenser is drawn fine but the water flow is incorrect. The end of the condenser is open, and the distillate will drip into the collection beaker so in effect acts as a vent.

This means that there are 4 MS points which equates to 2 marks.

ResultsPlus
Examiner Tip

Double-check any drawing for 'obvious errors' such as an open top when it should be closed.

Question 2 (e)

The majority of candidates were able to identify the solid particles in the flask. It tended to be faults in spelling that resulted in the mark not being awarded.

(e) Identify the solid particles labelled **A** in the flask that have been added to promote smooth boiling.

(1)

Anbi - granules

ResultsPlus
Examiner Comments

This response is lacking what the "anti" is referring to and so does not score.

ResultsPlus
Examiner Tip

Make time to check answers so that 'simple' mistakes can be corrected.

(e) Identify the solid particles labelled **A** in the flask that have been added to promote smooth boiling.

(1)

Pumping granules

ResultsPlus
Examiner Comments

In this response, the "anti" is missing and the following word should be 'bumping' and not "pumping". This was not a rare mistake.

ResultsPlus
Examiner Tip

Practise writing the correct names for chemicals and apparatus.

Question 2 (f)

The most common answer was to put a lid on the beaker to prevent loss of the bromoethane, but this did not score. It should be in a candidates experience that beakers do not have lids; they have a spout which would prevent such a lid. Only about a third of candidates correctly suggested that the beaker be cooled in ice or a cold water bath.

(f) Bromoethane is very volatile.
Suggest what could be done with the small beaker, used in Step **5** to collect bromoethane, in order to prevent the loss of the bromoethane distillate.

(1)

The beaker could be place in a water bath.

ResultsPlus
Examiner Comments

A water bath is used to maintain a constant temperature and normally they keep the reaction mixture at a warmer temperature than room temperature. Hence this response did not score as reference to cooling was required or mention of the use of an ice-bath.

ResultsPlus
Examiner Tip

Make sure that the correct term for the right situation is used.

Question 2 (g)

Many answers were seen where it seemed that the full question had not been read. The question begins with 'Describe how to use a separating funnel...' and so much of the answer space was taken up by descriptions of shaking the funnel, inverting it and opening the tap to relieve the pressure. All of these comments were ignored because the question continued '...to remove the aqueous layer from the bromoethane' so the separating funnel had already been used and the point of the question was how to divide or separate the two liquids.

The majority of candidates did show their understanding of the density values and identify the bromoethane as the bottom layer and gained one mark. The second mark was for a description of how to use the separating funnel by 'opening the tap' and letting the bromoethane out. Some candidates incorrectly referred to the stopper and not the tap and this did not score.

Some candidates described the addition of a drying agent to the separating funnel, but this should not be in a candidates experience and was tested in a latter step.

(g) Describe how to use a separating funnel to remove the aqueous layer from the bromoethane collected in Step **6**.
[Densities: bromoethane = 1.47 g cm^{-3} water = 1.00 g cm^{-3}]

(2)

· let two layers settle in the funnel e.g in a beaker
· run off lower organic layer to collect bromoethane ✓
· upper aqeous layer can be emand e.g pour out of the funnel

ResultsPlus
Examiner Comments

This response scored 1 mark for the reference to the presence of two layers with bromoethane being the lower layer. The comment "run off" the lower layer is not a sufficient description of how to use the separating funnel. The opening of the tap was specifically required for the second marking point.

(g) Describe how to use a separating funnel to remove the aqueous layer from the bromoethane collected in Step **6**.
[Densities: bromoethane = 1.47 g cm^{-3} water = 1.00 g cm^{-3}]

(2)

place both bromoethane and water in the funnel and the flip it and shake it, open it upside down and observe the ~~heavy~~ heavist layer will come out first and the lightest will come out less.

ResultsPlus
Examiner Comments

This candidate does understand what is happening with the separating funnel, but unfortunately has not answered the question about bromoethane.

Hence no mark is awarded.

ResultsPlus
Examiner Tip

Make sure that the answer given does refer to the substances stated in the question.

Question 2 (h)

This was another example where the lack of visualising the situation resulted in no mark being awarded. Candidates were expected to deduce that bromoethane would have a lower boiling point than water from a consideration of their studies on intermolecular forces. Hence the result of placement in a warm oven would be evaporation of the bromoethane and not the water.

(h) State why the bromoethane would **not** be dried in Step **7** by placing in a warm oven.

(1)

* Because atoms in bromoethene are strongly bonded temperature of oven is not enough.

ResultsPlus
Examiner Comments

This is an example of an answer that has misunderstood the situation. Any reference to decomposition did not score because the volatility or evaporating of the bromoethane is the separating of the molecules and not that they are broken down.

ResultsPlus
Examiner Tip

Make sure that you understand the difference between boiling and decomposition.

(h) State why the bromoethane would **not** be dried in Step **7** by placing in a warm oven.

(1)

As bromoethane is more volatile than water (lower boiling point) it will evaporate off first before water is

ResultsPlus
Examiner Comments

An excellent answer which nicely states why the use of a warm oven would not dry a sample of bromoethane.

Question 2 (i)

This was a novel question but not one that candidates have had no experience of in the sense of writing a formula with water of crystallisation. However, only the more able candidates scored this mark.

(i) A small quantity of water is removed by the drying agent anhydrous calcium chloride.

Complete the equation by adding the formula of the product including its state symbol.

(1)

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

ResultsPlus
Examiner Comments

This is an example of a response which misunderstood the use of a drying agent. The compound does not change and note that there are no chlorine atoms on the right hand side so the equation cannot be correct. Also, the question specifically requires a state symbol and this is missing.

ResultsPlus
Examiner Tip

Remember that all equations must balance for charge and atoms.

Make sure that all parts of the question are addressed. If state symbols are required, then they will be asked for.

Question 2 (j)

Chemical tests are generally well-known by candidates and this was one of the higher-scoring questions on the paper. Nonetheless, candidates still spoilt otherwise acceptable answers by including incorrect formulae of reagents or by giving additional observations that are not seen. In addition, it would be wise for candidates to refrain from describing 'secondary' tests such as the addition of ammonia to a silver halide precipitate when there was no need to do this. The formation of the cream precipitate of silver bromide was all that was needed for the test for the bromo group. Similarly, the addition of phosphorus(V) chloride to give misty fumes of HCL is sufficient and there is no need to go on and describe the use of ammonia to form white smoke of ammonium chloride. These additional details did not gain credit and took up valuable exam time.

(j) State a chemical test for the –OH group in ethanol and a chemical test for the –Br group in bromoethane. Include the expected positive observations.

(4)

–OH group in ethanol add PCl5 to ethanol. If -OH group is present, HCl will be form and white smoke will be ~~of observed. seen. formed.~~ seen.

–Br group in bromoethane add ~~H_2O P H_3PO_4~~ phosphoric acid to bromoethane. If ~~Br-~~Br group is present, Br_2 will be form and orange gas will be seen.

ResultsPlus
Examiner Comments

The test for an – OH group scored 1 mark.

The reagent is correct, but the observation is not white smoke, but white fumes. The observation of white smoke is made when HCl reacts with ammonia vapour and forms solid particles of ammonium chloride. These are not seen here.

The test for the – Br group is incorrect and has perhaps been mixed up with the test for bromide ions.

ResultsPlus
Examiner Tip

The use of precise terms is important and so make sure that the correct terms are used in the right places.

(j) State a chemical test for the –OH group in ethanol and a chemical test for the –Br group in bromoethane. Include the expected positive observations.

(4)

–OH group in ethanol Add anhydrous cobalt paper turns from blue → pink

–Br group in bromoethane Add $AgNO_3$ + nitric acid → cream precipitate (ppt) ($AgBr$)

ResultsPlus
Examiner Comments

The use of anhydrous cobalt(II) chloride paper is for the detection of the presence of water and not the alcohol group so does not score.

However, both marks were awarded for the test and result on the – Br group.

Question 3 (a)(i)

The Royal Society of Chemistry has a number of effective demonstrations to illustrate and explain chemical phenomenon and this is one of them. Centres and their candidates can benefit from such resources.

Once again, the responses seen frequently omitted key detail required in the question. For example, the question asked for an explanation of the 'observations' i.e. plural but only one comment was often seen. Furthermore, important detail given in the passage was also often missing and the prime illustration of this was the omission of the states. The desired answer was that more brown liquid was formed, then followed by more yellow solid. Only the more able candidates included this necessary detail.

Another key lesson that candidates need to note is the setting or context of the question. At the very start the question highlighted that this was an equilibrium demonstration. Hence the better answers would explain in terms of shifts in equilibrium position rather than simply that 'reaction would go to the right'. This was not always seen.

3 The equilibrium between iodine(I) chloride, chlorine and iodine(III) chloride can be used to demonstrate the effects of changing conditions on a system at equilibrium.

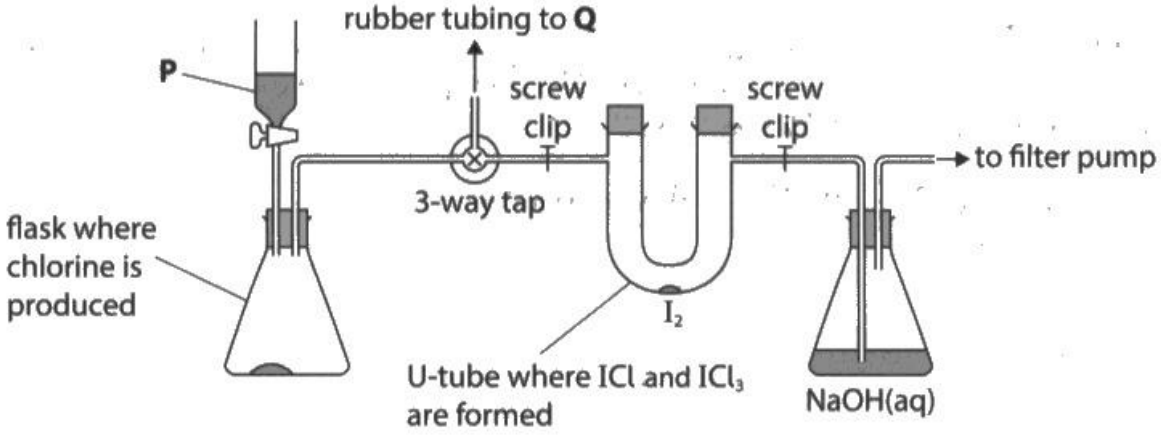
Iodine(I) chloride is formed by passing chlorine over iodine in a U-tube.
The equation for this is shown.

$$I_2 + Cl_2 \rightarrow 2ICl$$

A further reaction then occurs between the iodine(I) chloride and chlorine which results in the equilibrium shown.

$$\underset{\text{brown}}{ICl(l)} + \underset{\text{pale green}}{Cl_2(g)} \rightleftharpoons \underset{\text{yellow}}{ICl_3(s)} \qquad \Delta H = -106\,kJ\,mol^{-1}$$

The apparatus shown can be used to set up and then to demonstrate how the system at equilibrium responds to changing conditions.



(a) The addition of more liquid **P** to the flask on the left produces more chlorine gas.

(i) Explain the observations you would make as the amount of chlorine gas in the U-tube increases.

(3)

As more chlorine gas forms, a pale green and brown colour will show but the equilibrium will favour the forward reaction to reduce this gas and will cause a colour change of pale green and brown to yellow as ICl_3 forms.

ResultsPlus
Examiner Comments

This response scores 2 marks.

The mark for the shift in equilibrium to the right is awarded. Both the colour and the states were required for the observation marking points but if the states were missing, as in this case, then 1 mark was awarded for the two correct colours in the right order.

ResultsPlus
Examiner Tip

Take note of all the information given in the question. If the colour and state are given, then refer to both in your answer.

3 The equilibrium between iodine(I) chloride, chlorine and iodine(III) chloride can be used to demonstrate the effects of changing conditions on a system at equilibrium.

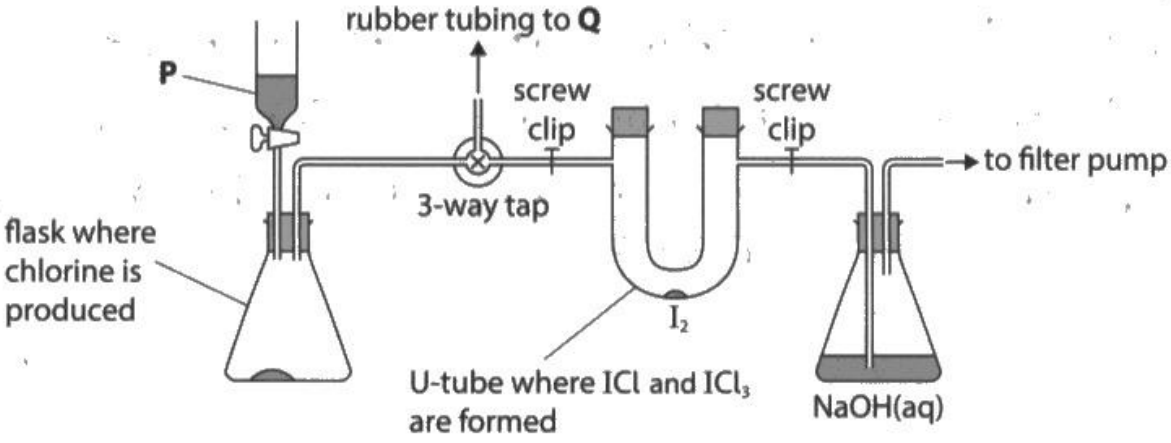
Iodine(I) chloride is formed by passing chlorine over iodine in a U-tube.
The equation for this is shown.

$$I_2 + Cl_2 \rightarrow 2ICl$$

A further reaction then occurs between the iodine(I) chloride and chlorine which results in the equilibrium shown.

$$\underset{\text{brown}}{ICl(l)} + \underset{\text{pale green}}{Cl_2(g)} \rightleftharpoons \underset{\text{yellow}}{ICl_3(s)} \qquad \Delta H = -106\,\text{kJ mol}^{-1}$$

The apparatus shown can be used to set up and then to demonstrate how the system at equilibrium responds to changing conditions.



(a) The addition of more liquid **P** to the flask on the left produces more chlorine gas.

(i) Explain the observations you would make as the amount of chlorine gas in the U-tube increases.

(3)

A pale yellowish green ~~gas gas can be seen~~ gas can be seen as it passes into the U-tube which would result in a brown liquid forming around the I_2 sample. A yellow solid would then be produced at the bottom. As more Cl_2 is put into the tube the amount of yellow solid would ~~increase~~ appear to increase.

ResultsPlus
Examiner Comments

This response has scored both observation marks, but not explained that these result from a shift in the equilibrium.

ResultsPlus
Examiner Tip

The best answers always refer to the shift in the equilibrium position. Other expressions are allowed but plan to use the best.

Question 3 (a)(ii)

This question proved to be another of the more challenging questions on the paper. Perhaps this was a lack of familiarity with the practical setup, but either way only a minority appreciated that Q was an outlet to the fume cupboard because of the toxic chlorine gas. A wide range of responses were seen that were not practical.

(ii) The 3-way tap can be used to prevent more chlorine gas from entering the equilibrium system.

Identify **Q** and state why it is necessary.

Rubber bung and a tube is passed through (2)

Escape tube to make chlorine gas to esape.

ResultsPlus
Examiner Comments

This response did not score.

The identity of Q was to a fume cupboard and so the reference to a bung and tube was insufficient. The statement that this was to enable the chlorine gas to escape was also insufficient. It might be asked why is it important to allow the gas to escape? The answer needed was that the gas is toxic.

ResultsPlus
Examiner Tip

Vague answers which refer to things such as cost or, as here, to allow to escape, are usually not enough to score. A statement is needed as to WHY these things are necessary, so make sure to elevate an answer with a reason.

Question 3 (b)

When considering the topic of equilibrium, candidates are expected to understand the effect of changes in concentration, pressure and temperature and so, having covered concentration in part (a)(i), it would make sense that part (b) was addressing one of the other two factors. The enthalpy change of the reaction was given in the stem of the question and so should have been a big clue. However, this was not always noted by candidates and those who appreciated the point that temperature was involved, simply stated to 'increase the temperature' without stating how. The question specifically asked "what could you do to the U-tube" and so a description of some action was required.

(b) Explain what you could do to the U-tube to result in more brown liquid being observed.

(2)

Increase the temperature of the U-tube which would cause equilibrium to shift to the left hand side which is endothermic so more $I_2(l)$ will be produced hence more brown liquid is observed.

ResultsPlus
Examiner Comments

This response scored 1 mark for the explanation that an increase in temperature would shift the equilibrium to the left or in the endothermic direction.

However, there is no mention of how the temperature will be increased or what would be done to the U-tube for this increase in temperature to occur. Hence no second mark was awarded.

ResultsPlus
Examiner Tip

Make sure that the question asked is answered and so "Read The Question Twice" or RTQ^2.

This question asks "what you could do to the U-tube" and so always address the specific parts of the question that are asked.

Question 3 (c)

Only a minority could correctly give the equation for the reaction of chlorine with cold, dilute sodium hydroxide.

On a positive note, it was good to see the majority of equations written were balanced. However, not all balanced chemical equations make chemical sense. For example, it was not unusual to see hydrochloric acid as a product, but this clearly won't happen when alkaline sodium hydroxide is a reactant. So candidates do need to keep this point in mind.

(c) The sodium hydroxide solution absorbs excess chlorine.

Write the equation for the reaction between cold, dilute sodium hydroxide and chlorine.
State symbols are not required.

(2)

~~$NaOH + Cl_2 \rightarrow NaClO_3 + HCl$~~

$NaOH + Cl_2 \rightarrow NaClO + HCl$

ResultsPlus
Examiner Comments

Although this equation is balanced and all of the species exist, no mark was awarded.

Responses such as this were not uncommon and it would have been helpful if the candidate had stopped and considered the situation. Sodium hydroxide is an alkali and so it will not react to produce the acid HCl.

ResultsPlus
Examiner Tip

Reflect on the context or circumstances of the situation being asked. If an acid or a base is a reagent then it is unlikely that the opposite of such will be a product.

Question 4 (a)

This question draws on Core Practical 2 and so candidates should have had experience to draw on. However, many candidates gave the reason for the beaker as insulation and prevention of heat loss rather than to stabilise the polystyrene cup.

This is another reminder of the value of the Core Practicals in revision.

4 An experiment was carried out to determine the enthalpy change of neutralisation for the reaction between sulfuric acid and sodium hydroxide.

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

Procedure

Step **1** 25.0 cm^3 of 1.25 mol dm^{-3} sulfuric acid was placed in a polystyrene cup. The polystyrene cup was then placed in a beaker. A thermometer was used to measure the temperature of the acid and a clock was started.

Step **2** The temperature of the sulfuric acid was measured every 30 seconds for 2½ minutes.

Step **3** 50.0 cm^3 of 1.25 mol dm^{-3} sodium hydroxide solution was added to the acid in the polystyrene cup at 3 minutes and the mixture was constantly stirred.

Step **4** The temperature of the mixture in the polystyrene cup was measured at 3½ minutes and then every 30 seconds until the clock reached 10 minutes.

(a) Give the reason why the polystyrene cup in Step **1** was placed in a beaker.

(1)

To act as a second barrier to prevent further heat loss.

ResultsPlus
Examiner Comments

This is an example of a very common incorrect response. The use of a glass beaker was not to increase the insulation or to prevent heat loss.

ResultsPlus
Examiner Tip

The Core Practicals include many key points and should always be a part of exam revision.

4 An experiment was carried out to determine the enthalpy change of neutralisation for the reaction between sulfuric acid and sodium hydroxide.

0.03125 0.0625

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

25cm³

1.25mol dm⁻³

Procedure

Step **1** 25.0 cm^3 of 1.25 mol dm^{-3} sulfuric acid was placed in a polystyrene cup. The polystyrene cup was then placed in a beaker. A thermometer was used to measure the temperature of the acid and a clock was started.

Step **2** The temperature of the sulfuric acid was measured every 30 seconds for 2½ minutes.

Step **3** 50.0 cm^3 of 1.25 mol dm^{-3} sodium hydroxide solution was added to the acid in the polystyrene cup at 3 minutes and the mixture was constantly stirred.

Step **4** The temperature of the mixture in the polystyrene cup was measured at 3½ minutes and then every 30 seconds until the clock reached 10 minutes.

(a) Give the reason why the polystyrene cup in Step **1** was placed in a beaker.

(1)

to stabilise the cup

ResultsPlus
Examiner Comments

A brief and clear answer which scored the mark.

Question 4 (b)

There were some good answers which showed an understanding of the need to establish an average temperature or to allow equilibration with the room temperature. Reference just to recording an "accurate" temperature was not sufficient to score.

(b) State the purpose of measuring the temperature every 30 seconds for 2½ minutes in Step **2**.

(1)

Getting more results for a more accurate graph

ResultsPlus
Examiner Comments

Answers which refer to something being "more accurate" will rarely score unless some justification is given.

This type of response was frequently seen and did not score.

ResultsPlus
Examiner Tip

Be specific and not vague when answering.

(b) State the purpose of measuring the temperature every 30 seconds for 2½ minutes in Step **2**.

(1)

To ensure the initial temperature of the acid was constant.

ResultsPlus
Examiner Comments

A clear answer which addressed the point and scored the mark.

Question 4 (c)

This is a practical paper and so there will always be questions that address the experimental steps that are taken. If the sodium hydroxide solution is added at 3 minutes, then it would not be practical at the same time to record the temperature. A good number of candidates appreciated that the thermometer would be being used to stir the mixture instead of recording the temperature and this was given a mark.

(c) Explain why the temperature was not measured at 3 minutes.

(2)

Because at 3minutes the NaOH was added, and instantly at the moment the temperature does not increases, it takes time to do the change in heat energy.

ResultsPlus
Examiner Comments

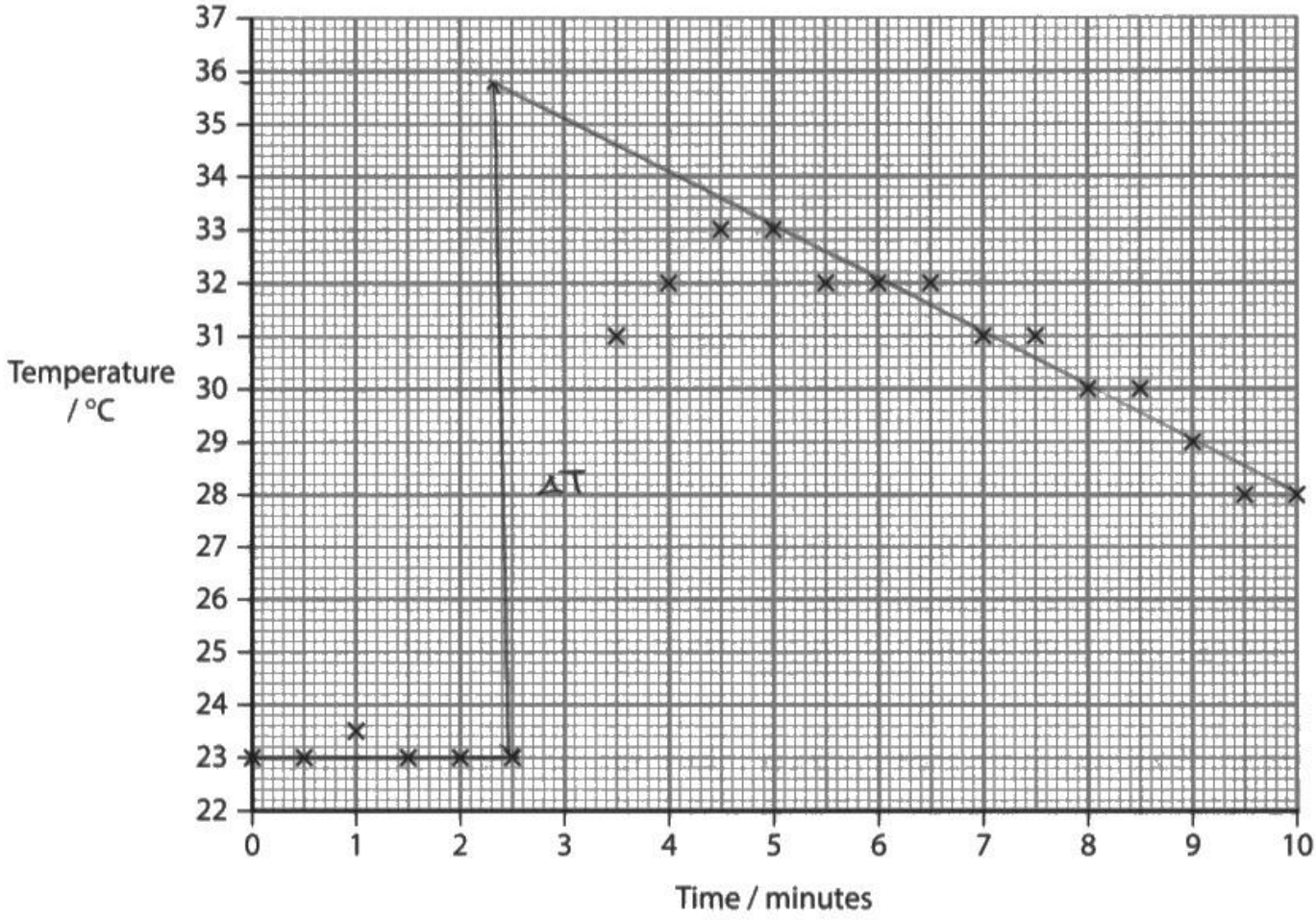
This response scored 1 mark for the acknowledgement that at 3 minutes the NaOH was being added.

However, the reaction is instantaneous and so the temperature will be increasing.

Question 4 (d)(i)

This question followed on immediately from the point that the temperature was not recorded at 3 minutes as this was the start of the reaction. Hence it was at 3 minutes that the temperature change should be determined. The majority of candidates did understand the need to extrapolate back in time, but this was not always done to 3 minutes, and even those who did extrapolate back, it was not all that measured the temperature change at the time of 3 minutes. Hence this question was lower-scoring than had been hoped.

(d) The data from the experiment are shown on the graph.



(i) Determine the maximum temperature change, ΔT, for this reaction, using the graph.
You **must** show your working on the graph.

(2)

35.8 − 23 = 12.8 °C //

ResultsPlus
Examiner Comments

1 mark was awarded for the extrapolation of the line back to three minutes or beyond.

However, it is clear that the temperature change being determined is at 2.5 minutes and not 3 minutes which is when the sodium hydroxide was added so no second mark. The previous question had just asked about the activity at 3 minutes so it should have been in the candidates mind.

ResultsPlus
Examiner Tip

Take note of the sequence of questions because oftentimes they can follow on from each other.

Question 4 (d)(ii)

It became apparent that there is a significant misunderstanding in the minds of many candidates with respect to the speed of chemical reactions. The reaction of a strong acid and a strong base is instantaneous, but the transfer of the heat energy is not. Hence the data shows an initial increase in temperature before it decreases. This is not because the reaction is slowing down, as many candidates suggested, but rather that there is no more heat energy being released and instead heat is being lost to the surroundings.

(ii) Explain why the temperature decreases over time after 5 minutes.

(2)

Because all the Sulfuric acid has reacted so the graph will level off.

ResultsPlus
Examiner Comments

1 mark was awarded for the reference to the sulfuric acid having fully reacted, but there is no comment as to why the temperature then will decrease.

ResultsPlus
Examiner Tip

Make sure that an answer makes as many points as there are marks for the question.

(ii) Explain why the temperature decreases over time after 5 minutes.

(2)

At 5 minutes, the maximum temperature shows that the reaction has fully occurred. As the reaction is exothermic, no more heat is being given off by the reaction mixture. ~~Heat~~ is Heat loss of the surroundings such as the beaker or cup

ResultsPlus
Examiner Comments

An example of a response which clearly makes both points and scores 2 marks.

Question 4 (d)(iii)

This was another question based around the equipment being used but only the better candidates realised that the lack of change in temperature was simply due to the lack of resolution on the thermometer. It was not sufficient to state that the reading of the thermometer was wrong because that it a fault of the experimenter and not the equipment.

(iii) Give a possible reason why the temperature does not appear to change at various times, such as 5½ to 6½ minutes.

(1)

① reaction is ~~to~~ slow and requires time to show temperatur change.

ResultsPlus Examiner Comments

Answers such as this which referred to the slowness of the reaction did not score. The reaction is instantaneous. The 'flow' of energy through the system was not the answer required.

(iii) Give a possible reason why the temperature does not appear to change at various times, such as 5½ to 6½ minutes.

(1)

Because the thermometer does not have the resolution required. ~~to measure~~

ResultsPlus Examiner Comments

An excellent answer which clearly identifies the thermometer as the issue.

Question 4 (d)(iv)

The word 'standard' was put in bold font to serve as a hint to the candidates of the direction that their answer should go. This was not always appreciated and oftentimes candidates simply re-stated the question by stating that conditions were not standard which was insufficient. Candidates needed to specifically refer to the temperature being the key factor.

(iv) State why the data will not result in the **standard** molar enthalpy change of neutralisation being calculated.

(1)

Because it is not carried out under standard conditions most of the time

ResultsPlus
Examiner Comments

It was insufficient to give a vague answer like this about standard conditions. The temperature needed to be identified.

ResultsPlus
Examiner Tip

Remember that generally questions increase in demand the further on in the paper and oftentimes more is required than a simple answer.

(iv) State why the data will not result in the **standard** molar enthalpy change of neutralisation being calculated.

(1)

More than 1 mol of H_2O formed

ResultsPlus
Examiner Comments

This is not an incorrect statement in that the equation does show two moles of water being produced, but this is 'factored in' during the calculation. The answer required was something else and so this did not score.

Question 4 (e)(i)

Candidates were allowed to argue either for or against validity, but it was disappointing that examiners were made to work hard to determine which way the candidates were arguing because it was often not made clear.

The assumption could be argued not to be valid because the specific heat capacity of the acid is different from water. Or the assumption could be argued to be valid because the majority of the acid is water.

A common incorrect response was to refer to water as the product, but there was already a large quantity of water present and so this was ignored. Another incorrect approach was to comment on the different densities of the solutions, but this question was about the specific heat capacities and so was also ignored.

(e) When calculating the enthalpy change of neutralisation, the two expressions shown are used.

$$\text{energy transferred} = \text{mass} \times \text{specific heat capacity} \times \text{temperature change}$$

$$\text{enthalpy change} = \text{energy transferred} \div \text{moles}$$

(i) Explain why it may or may not be valid to assume that the specific heat capacity of water is suitable to be used for this reaction.

(2)

concentration of solutions added is not the same as water. this changes the density of the solution and hence enthalpy change is less than it should be.

ResultsPlus
Examiner Comments

It was not unusual to see this kind of response which does not actually state if the view is that it is valid to use the specific heat capacity of water or not. References to density were ignored since this was not the subject of the question. Hence no mark awarded.

ResultsPlus
Examiner Tip

If a question requires a decision or a judgement plus a justification, then make sure that the decision is clear and then the justification is given. The decision can be stated at the end, but the danger is that it can be forgotten.

(e) When calculating the enthalpy change of neutralisation, the two expressions shown are used.

$$\text{energy transferred} = \text{mass} \times \text{specific heat capacity} \times \text{temperature change}$$

$$\text{enthalpy change} = \text{energy transferred} \div \text{moles}$$

(i) Explain why it may or may not be valid to assume that the specific heat capacity of water is suitable to be used for this reaction.

(2)

It is valid as the concentration of solute in solution is very low which does not change the specific heat capacity very much. The majority is water.

ResultsPlus
Examiner Comments

An excellent answer which made the point for validity clearly and scored both marks.

Question 4 (e)(ii)

Whether it was because this was the end of the paper or that candidates just hadn't looked at the question enough is unclear, but the answer most frequently seen stated that either the acid or the alkali was in excess. In fact, neither was the case. If the candidates had quickly done a moles calculation, then they would have seen that the molar ration was exactly as the stoichiometry of the equation. The key point of this question was that the enthalpy of neutralisation of per mole of water and in the equation, there are two moles of water formed. Less than 10% of candidates got this mark.

(ii) State why the number of moles of sodium hydroxide and **not** the number of moles of sulfuric acid is used in the calculation for this experiment.

(1)

Because NaOH is in excess. H_2SO_4 is a limiting reactant.

ResultsPlus
Examiner Comments

Here is an example of a very common response which was incorrect. The NaOH was not in excess and so no mark was awarded.

Paper Summary

Based on their performance on this paper, candidates should:

- Always re-read the question asked and make sure that their answer does address the question asked.
- Pay particular attention to the information given in the text passages of the question because there are often key points which are needed to effectively answer the questions.
- Include the Core Practicals in their revision because they teach important chemical techniques and procedure.
- Take care to understand the reason for a particular step or piece of apparatus so that an explanation can be given if called upon.
- Practise drawing laboratory apparatus and experiment setups so that these are clear and error-free.
- Research chemical demonstrations which will increase understanding, such as those available from the Royal Society of Chemistry.
- Avoid giving more than one answer to a question.
- Make time to check and to double-check your answers so that any simple corrections, as necessary, can be made.