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Examiners' Report
June 2022

GCSE Chemistry 1CH0 1H

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June 2022

Publications Code 1CH0_1H_2206_ER

Introduction

Paper 1CH0_1H is the first of two papers that make up the GCSE Chemistry (Higher tier). Questions 2, 3 (apart from 3(c)) and 4 were common with the foundation tier 1F paper, and six questions that assessed Topics 1, 2, 3 and 4 of the specification formed the GCSE Combined Science (Chemistry) higher tier paper, 1SC0_1CH. This paper assessed Topics 1, 2, 3, 4 and 5 of the specification.

This was the first time that GCSE Chemistry was taken under normal conditions since June 2019, although candidates and schools had access to the Advance Information which gave information about which topics were and were not being assessed. This Advance Information also listed the core practicals that were also being assessed. Marking took place as usual and grade boundaries were set under the guidance of OFQUAL so the standards would be somewhere between those of 2019 and 2021.

Question 1 (a)

Most of the candidates just gave the simple answer of the bulb becoming dim over a long period, with only a minority adding that the bulb would eventually go out, which was the second mark for this item. A few did start their answer with the bulb shining bright to start with and picked up the second mark by stating that the bulb would dim over time. Most of the candidates thought there was more to this than simply describing what happened to the bulb and they went on to try to explain why the bulb became dimmer; however, there was no credit for that. The question specifically asked the candidate to describe what happened to the bulb rather than explain what happened to the bulb over a long period of time.

Describe what will happen to the brightness of the light bulb over a long period of time.

(2)

It will get brighter as the copper and zinc ions are in the sodium chloride solution meaning the solution can conduct electricity

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Examiner Comments

The idea here was seen in a sizeable number of candidates' answers. 'It will get brighter' means the current will increase, which isn't the case.

This scored 0.

Describe what will happen to the brightness of the light bulb over a long period of time.

(2)

The brightnen of the lamp will ~~[illegible]~~ decrease over time as the copper electrode will eventually run out and the lamp will not work anymore as voltage decreases and stops.

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Examiner Comments

This candidate scored for making the points that the brightness of the bulb will decrease and will eventually go out.

2 marks scored

Describe what will happen to the brightness of the light bulb over a long period of time.

(2)

It would ~~[illegible]~~ get dimmer because there would be a slower flow of anions and cations carrying the charge.

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Examiner Comments

Many candidates tried to explain why the brightness of the bulb would decrease; some with more success than others.

This scored 1 mark.

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Examiner Tip

Candidates need to understand the difference between types of questions that are on the examination paper. Any explanation given in this type of question will not score, no matter how good an explanation is given as it does not answer the question.

Question 1 (d)

This question was designed to show if candidates could draw the irregular arrangement of metal atoms present in an alloy. They were provided with the information that the zinc atoms were slightly larger than the copper atoms, but many did not read this or chose to ignore this. They were also told that the alloy in this question (one type of brass) contained 70% copper, another piece of information many did not read. There were a significant number of candidates whose diagrams resembled alternating layers of the two metal atoms, so not irregular and containing an equal number of copper and zinc atoms. Again, many drew diagrams that were difficult to credit, since all the circles were either of a similar size or completely random with labels to distinguish the two metals' atoms. But overall, about half the candidates managed to score 1 mark for their diagram. It would be good to see candidates having some experience of drawing structures like this to represent states of matter, and in this case an alloy.

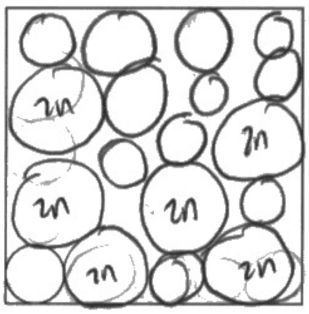
(d) Brass is an alloy of copper and zinc.
One type of brass contains 70% copper.

Zinc atoms are slightly larger than copper atoms.

Draw a labelled diagram in the box to show the arrangement of copper and zinc atoms in this alloy.

Use the circle in the box as a guide to the size of a copper atom.

(2)



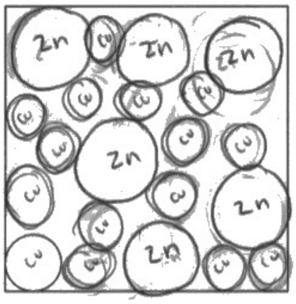
ResultsPlus Examiner Comments

The copper atoms are not labelled and appear to be all different sizes, however it is clear they are copper as the zinc has been labelled. They only had to label copper or zinc, not both to show the difference. Copper and zinc are found in a 12:6 ratio which was close enough to 7:3 so the second marking point can be achieved.

This scored 2 marks

Use the circle in the box as a guide to the size of a copper atom.

(2)



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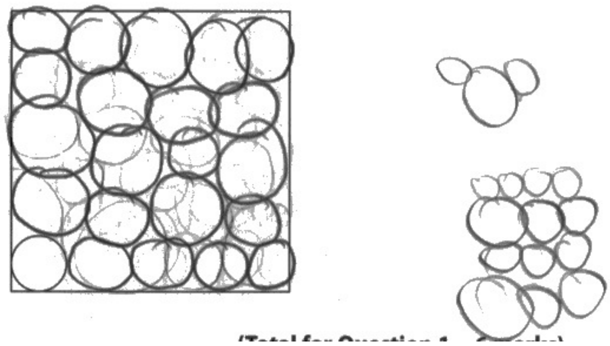
Examiner Comments

The candidate had labelled the individual zinc and copper atoms. The atoms are shown close together and are of different sizes, therefore the first marking point can be achieved. The ratio drawn is 15:6 copper to zinc so was acceptable for the 2nd mark point.

2 marks

Use the circle in the box as a guide to the size of a copper atom.

(2)



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Examiner Comments

Examiners saw many answers like this. It wasn't clear which circles represented copper atoms and which represented zinc atoms.

This scored 0 marks.

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Examiner Tip

Simple shading or somehow indicating the difference between the copper and zinc atoms might have helped for this candidate to score full marks.

Question 2 (b)(i)

Nearly 90% of the candidates gave the answer of burette or pipette. Non-scoring answers that were given included measuring cylinder, beaker and 'titration tube'.

Question 2 (b)(ii)

Candidates were asked to describe how the pH of a mixture could be determined, but although a good number did start by stating that they should look at the colour produced, not so many then said that they should compare the colour obtained with a pH chart to determine the pH of the mixture. As an alternative approach, as seen by many candidates, they could state that the colour changed to, say, red if it was acidic, but they still needed to compare that colour to the pH chart to find the actual pH. Many candidates here just listed the colours.

(ii) Describe how the <u>pH of the mixture</u> is determined <u>when a drop</u> of it is placed on the universal indicator paper.

(2)

The colour of the paper once the indicator is put on the mixture should be compared to a pH scale ~~in orde~~ so that the pH of the solution can be read from the pH scale giving the pH of the mixture.

ResultsPlus
Examiner Comments

This answer scored both marks for saying that the indicator changed colour and how to find the pH by comparing the colour to that on the pH scale.

(ii) **Describe how the pH of the mixture is determined when a drop of it is placed on the universal indicator paper.**

(2)

The universal indicator paper will change colour to ~~be~~ show the pH. Each colour correlates to a different pH eg. dark red would be 0, green would be neutral (pH 7).

ResultsPlus
Examiner Comments

Only 1 mark was scored here for saying that indicator paper would change colour. There was no mention of **how** the pH could be obtained from the colour of the indicator paper.

Question 2 (b)(iii)

Most candidates appreciated that litmus could only be used to show if a solution was acidic or alkaline (with many getting the specific colours correct), but not so many stated that litmus could not be used to show **how** acidic or **how** alkaline the solution was. An alternative approach, still creditworthy, was where candidates said that litmus only showed two colours or did not show a range of colours (as for Universal Indicator), so litmus would not give the pH (for the second mark). This question did show that many candidates think that pH can be found using litmus paper.

(iii) In the method, universal indicator paper is used to determine the pH.

Explain why litmus paper would not be a suitable indicator to use in this experiment.

(2)

Because it does not show a gradual change using litmus paper - there is only a colour change when all of the substance is neutralised, while universal indicator shows the gradual / progression of change.

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Examiner Comments

The candidate stated that Universal Indicator shows a gradual change in colour whereas litmus paper did not, scoring the first marking point. There was no mention of litmus paper failing to tell us how acidic the solution is or the pH so the second marking point did not score.

This scored 1 mark.

(iii) In the method, universal indicator paper is used to determine the pH.

Explain why litmus paper would not be a suitable indicator to use in this experiment.

(2)

Litmus paper does not determine pH, it only determines if a solution is alkali or acidic.

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Examiner Comments

'does not determine pH' was sufficient for the second marking point. The first marking point was contained in the second half of the answer.

This scored 2 marks.

(iii) In the method, universal indicator paper is used to determine the pH.

Explain why litmus paper would not be a suitable indicator to use in this experiment.

(2)

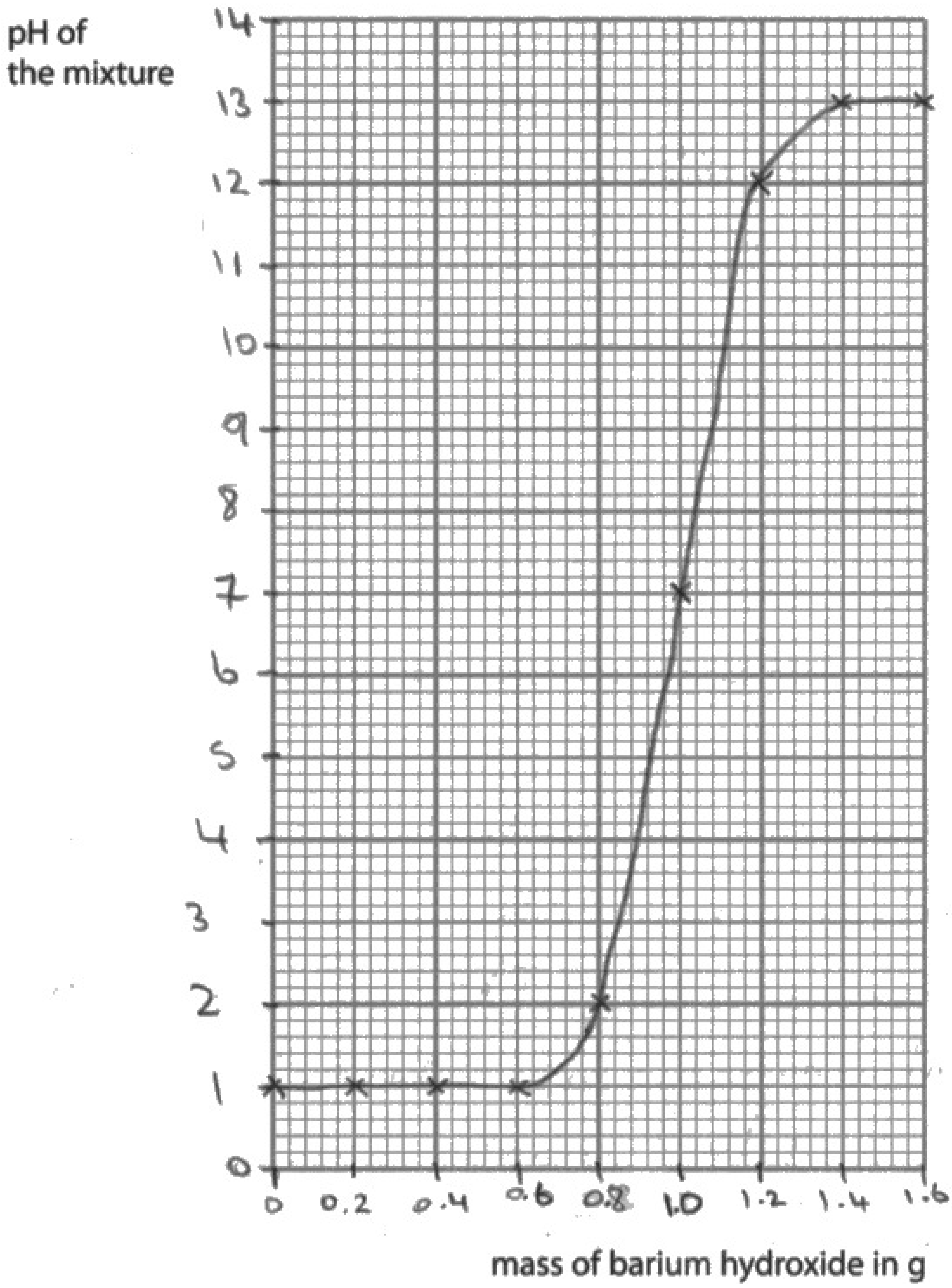
litmus paper reacts with chlorine so using it would determine if chlorine is present not the pH of the solution.

ResultsPlus
Examiner Comments

Many candidates confused the use of litmus paper to determine acidity/alkalinity with the test for chlorine. These answers did not score.

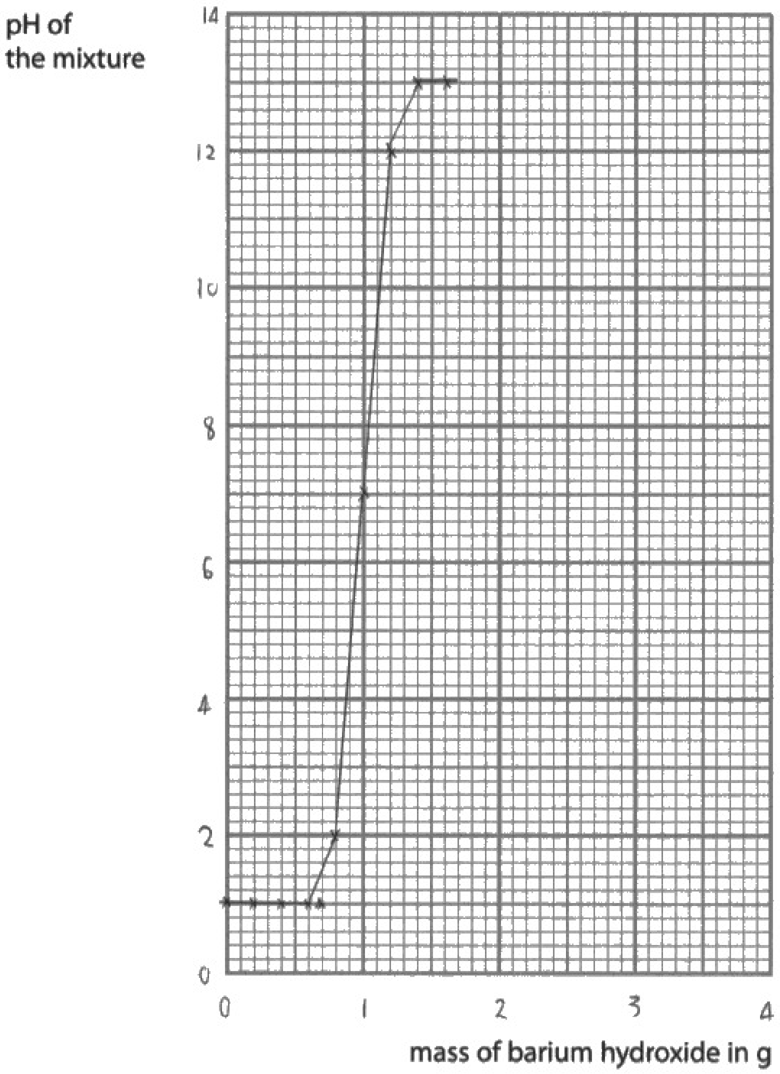
Question 2 (b)(iv)

This was a very straightforward graph for the candidates to plot with the overwhelming majority scoring all 3 marks, but there were still some who had difficulty in producing linear scales, plotting the points precisely, or ensuring that the plotted points occupied more than half the grid provided. The best-fit curve was not asked for, as this was an overlap question with the Foundation tier, and it was thought that would penalise many candidates at that level as they were less likely to have seen a graph of that shape. Examiners would find it much easier to check for accuracy of plotted points if a cross were to be used rather than just a dot.



ResultsPlus
Examiner Comments

This was a high scoring question on this paper. It was straightforward for candidates to achieve all three marks.



ResultsPlus
Examiner Comments

This graph scored for all points being plotted correctly. However it did not score for the first marking point since the plotted points did not cover at least half the grid in the horizontal direction.

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Examiner Tip

When plotting graphs on examination papers, grids are provided that allow candidates to select a suitable scale. Plotted points should also cover more than half the grid in both directions.

Question 3 (a)(ii)

There were many good answers seen here explaining why the metal magnesium could conduct electricity, but the compound magnesium carbonate could not. Some candidates tried using 'charged particles' in their answer, but this term was not credited as it was not clear whether they meant ions or electrons. So, we were looking for ions in solid magnesium carbonate being unable to move and delocalised electrons in magnesium able to move that explained the difference in conductivity. Some thought that it was the presence of 'carbonate' that stopped the compound from conducting an electric current. Several candidates thought that delocalised electrons in magnesium 'carried the charge'. However, about a quarter of the candidates scored full marks here.

(ii) Explain why solid magnesium carbonate cannot conduct electricity but solid magnesium can.

(3)

Solid magnesium can conduct electricity, as it has free electrons, which can carry a charge. Magnesium carbonate cannot conduct electricity as there are no free electrons, they are all bonded.

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Examiner Comments

This answer has said that magnesium contains free electrons but has not said these electrons can move. The point about magnesium carbonate having no free electrons to explain why it does not conduct was given a mark.

This scored 2 marks.

ResultsPlus
Examiner Tip

Avoid the use of 'charged particles'. In some situations this term is ambiguous as it would cover both ions and electrons.

(ii) Explain why solid magnesium carbonate cannot conduct electricity but solid magnesium can.

(3)

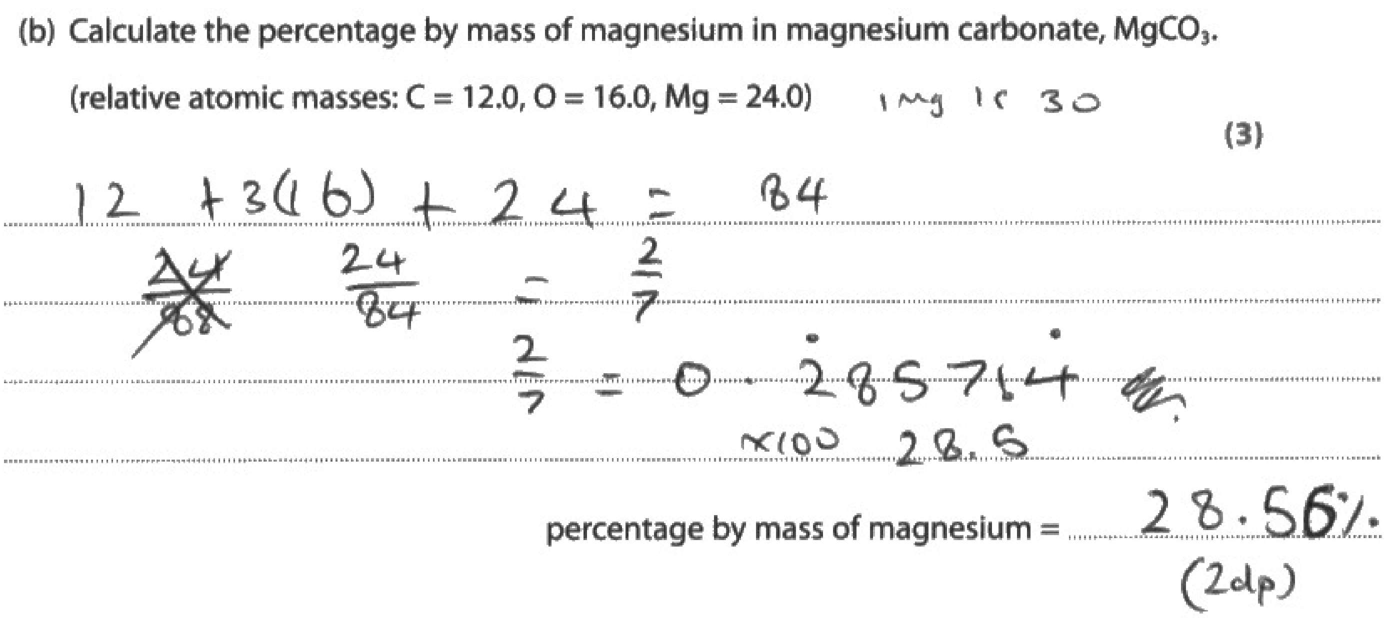
Because magnesium carbonate is an Ionic compound and Ionic compounds cannot conduct electricity when Solid due to a lack of free-flowing Ions. Solid Magnesium can conduct electricity because it is an alkali metal.

ResultsPlus
Examiner Comments

This scored just the 1 mark for the reason why solid magnesium carbonate cannot conduct electricity.

Question 3 (b)

In this calculation, the first mark was for calculating the relative formula mass of $MgCO_3$. Although most achieved that, errors seen at this stage were carried through with the rest of the calculation. At this point the most common error seen was to calculate the relative formula mass of just the carbonate; that was followed by 24/60 x 100. The other major problem here was seen where candidates approximated their answers. Some incorrectly approximated the answer to 28.5% and this lost them the 3rd mark, but the greater majority scored all 3 marks.



(b) Calculate the percentage by mass of magnesium in magnesium carbonate, $MgCO_3$.

(relative atomic masses: C = 12.0, O = 16.0, Mg = 24.0) 1 Mg 1 C 3 O

(3)

12 + 3(16) + 24 = 84

~~24/68~~ 24/84 = 2/7

2/7 = 0.285714

×100 28.5

percentage by mass of magnesium = 28.56%
(2dp)

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Examiner Comments

A correct answer until the incorrect rounding to 28.56% loses the last marking point.

This scored 2 marks out of the 3.

(b) Calculate the percentage by mass of magnesium in magnesium carbonate, $MgCO_3$.

(relative atomic masses: C = 12.0, O = 16.0, Mg = 24.0)

(3)

Mg C O3 24+12+48=84 24/84

24 12 48

84 ÷ 24 = 3.5

percentage by mass of magnesium = 35 %

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Examiner Comments

Relative formula mass was correctly calculated – 1 mark.

Alternative divisions were shown, but the candidates decided to go with the division 84/24 which was incorrect. Following that, the conversion of 3.5 to a % was also incorrect.

This scored just the 1 mark.

Question 3 (c)

It was disappointing to see that about a third of the candidates could not balance the equation by the inclusion of the formula $MgCl_2$ for magnesium chloride. Mostly they gave the answer of MgCl, and a sizeable number tried to adjust the numbers in front of the other substances in the equation.

(c) Magnesium carbonate reacts with dilute hydrochloric acid.
Water and carbon dioxide are two of the products of the reaction.

Complete the balanced equation for this reaction.

(1)

$$2MgCO_3 + 2HCl \rightarrow \text{~~MgCl}_2\text{~~ } 2MgCl_2 + 2H_2O + 2CO_2$$

ResultsPlus
Examiner Comments

The candidate has written the correct formula for magnesium chloride, but they then tried to balance this equation by multiplying everything by 2. If they had done this correctly they could have scored the mark. Unfortunately they did not correct the HCl so no mark was given.

ResultsPlus
Examiner Tip

Practice writing and balancing equations.

(c) Magnesium carbonate reacts with dilute hydrochloric acid.
Water and carbon dioxide are two of the products of the reaction.

Complete the balanced equation for this reaction.

(1)

$$MgCO_3 + 2HCl \rightarrow MgCl_2 + H_2O + CO_2$$

ResultsPlus
Examiner Comments

The candidate has written the correct formula for magnesium chloride so scored the mark.

Question 4 (a)(i)

Most candidates could state what was meant by the term 'actual' yield, but the main difficulty was seen with theoretical yield. We were not crediting 'predicted' or 'expected' without an indication of why it would be 'predicted' or 'expected' – ie by calculation. Many candidates just twisted around what was contained in the question to produce their answer, eg actual yield – the yield that was actually obtained. We were looking for understanding of these terms. Another common error was seen when candidates referred to reactants rather than products when explaining the terms.

(i) State the meanings of the terms **actual yield** and **theoretical yield**.

(2)

actual yield

How much mass of product was actually produced during the reaction

theoretical yield

How much mass of product we predicted would be formed during the reaction.

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Examiner Comments

1 mark was given for the meaning of the term 'Actual yield', but many candidates struggled to explain the meaning of 'Theoretical yield'. '... mass of product we predicted ...' alone was not enough – ideally it needed to be backed up as '... mass of product predicted by calculation ...'.

This answer scored 1 mark.

(i) State the meanings of the terms **actual yield** and **theoretical yield**.

(2)

actual yield

The yield of product that has ~~actually~~ actually ~~should have~~ been made by the experiment

theoretical yield

The yield of product that it should be according to calculations.

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Examiner Comments

Many candidates struggled to avoid the use of 'yield' in their answers, but this example showed that the candidate clearly understood the difference between the two terms.

This scored 2 marks.

Question 4 (a)(ii)

This calculation was correctly performed by almost all candidates. There were a few that subtracted the actual yield (8.07 g) from the theoretical value (53.80 g) and used that number as the theoretical yield; it was not clear why this was done.

(ii) Use the information in Figure 3 to calculate the percentage yield of ethanol in this experiment.

(2)

$\frac{8.07}{53.8} \times 100 = 15\%$

percentage yield = 15%.

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This was a very straightforward calculation.

This answer scored 2 marks.

(ii) Use the information in Figure 3 to calculate the percentage yield of ethanol in this experiment.

(2)

53.80 - 8.07 = 45.73 = actual

$\frac{45.73}{53.80} = 0.85 \times 100 = 85\%$

percentage yield = 85

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Examiner Comments

Examiners reported seeing this first line on the calculation by several candidates and it wasn't clear why that step was being taken. The equation for the calculation was given, so it was a simple task just to substitute the actual and theoretical yields into the equation to obtain the final answer.

This answer did not score the 1st mark, but did score the second mark for converting the fraction used into a percentage value.

Question 4 (a)(iii)

Why the actual yield is less than the theoretical was answered well by many candidates, with most giving the answers of incomplete reaction (or not all reactants used up) and stating that some product was lost in a process used to separate out the product. There were some instances of careless use of language examples included 'not all the product was used up' and 'some reactant was lost when extracting it'. We didn't credit any self-deprecating answers such as spillages.

(iii) State **two** reasons why the actual yield of a reaction is usually less than the theoretical yield.

(2)

1 Incomplete reaction,

2 Some reactants is left in containers and not used.

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Examiner Comments

'Incomplete reaction' was a common response and was awarded a mark for the 1st marking point,

'Some reactant is left in containers' was the same marking point as the first so did not score.

This answer scored 1 mark.

(iii) State **two** reasons why the actual yield of a reaction is usually less than the theoretical yield.

(2)

1 There may be impurities that didn't react of reactants ~~pro~~

2 The exact amount may not have been measured properly

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Examiner Comments

No credit was given for answers in terms of human error, such as 'not measured correctly' or 'spilt something'. The first point about impurities present that didn't react was credited with a mark.

This answer scored 1 mark.

(iii) State **two** reasons why the actual yield of a reaction is usually less than the theoretical yield.

(2)

1 Unwanted side reactions

2 Residue left on equiptment

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Examiner Comments

'Unwanted side reactions' scores a mark for marking point 3.

Residue left behind on equipment was sufficient for product lost during the reaction processes for the second marking point.

This answer scored 2 marks.

Question 4 (b)(i)

This calculation was a little more troublesome than first thought. There were several places where candidates made errors. These included adding up the relative formula masses for all the substances and using that as the denominator in the calculation, adding together just the formula masses of the products (46+44) and using that as the denominator, missing out that 4 moles of ethanol were produced, and not approximating the answer to the required 2 significant figures as asked for in the question. There were some misunderstandings seen where a few candidates gave the answer as '51.11% (to 2 sig figs)' so mistaking decimal places with significant figures. Despite all that, almost half of the candidates scored full marks.

(b) The balanced equation for the fermentation of sucrose is

$$C_{12}H_{22}O_{11} + H_2O \rightarrow 4C_2H_5OH + 4CO_2$$

(i) Calculate the atom economy of this reaction to produce ethanol.

Give your answer to two significant figures.

(relative formula masses: $C_{12}H_{22}O_{11}$ = 342, H_2O = 18, C_2H_5OH = 46, CO_2 = 44)

(3)

$4C_2H_5OH$ = 46 × 4 = 184 $4CO_2$ = 4 × 44 = 176

$\frac{184}{184+176} = \frac{184}{360} \times 100 = 51.1\% = 51\%$ (2 s f)

atom economy = 51 %

ResultsPlus Examiner Comments

This was a well-executed calculation with the answer correctly given to 2 significant figures.

This scored 3 marks.

(b) The balanced equation for the fermentation of sucrose is

$$C_{12}H_{22}O_{11} + H_2O \rightarrow 4C_2H_5OH + 4CO_2$$

(i) Calculate the atom economy of this reaction to produce ethanol.

Give your answer to two significant figures.

(relative formula masses: $C_{12}H_{22}O_{11}$ = 342, H_2O = 18, C_2H_5OH = 46, CO_2 = 44)

(3)

$\frac{46}{46 + 44} \times 100 = 51.11$

atom economy = 51.11 % %

ResultsPlus Examiner Comments

The atom economy here has been calculated by taking the relative formula mass of the product ethanol and dividing by the sum of the relative formula masses of both products and converting it into a percentage. This was correct up to that point, but this lost the final mark as the answer was not given to 2 significant figures.

(b) The balanced equation for the fermentation of sucrose is

ETHANOL → SUCROSE

$$C_{12}H_{22}O_{11} + H_2O \rightarrow 4C_2H_5OH + 4CO_2$$

(i) Calculate the atom economy of this reaction to produce ethanol.

Give your answer to two significant figures. Ethanol?

(relative formula masses: $C_{12}H_{22}O_{11} = 342$, $H_2O = 18$, $C_2H_5OH = 46$, $CO_2 = 44$)

(3)

360+46+44=450 $\frac{342}{450} \times 100 = 76\%$

342+18=360 46+44=90 $\frac{46}{90} \times 100 = 51 \cdot 1 \rightarrow 51\%$

$\frac{342}{360} \times 100 = 95\%$

atom economy = ... %

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Examiner Comments

This candidate has offered 3 different calculations – the middle one is correct, but since the candidate is offering a list of calculations with at least one incorrect one, so this does not score any marks. Had the answer of 51% appeared on the answer line, then 3 marks would have been awarded as it would be clear which the candidate was choosing as the correct calculation.

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Examiner Tip

Examiners do not choose the best answer from a list of possible ones that may be produced.

Question 4 (b)(ii)

The more astute candidates realised that if the carbon dioxide was then used to make fizzy drinks, it became a useful product in addition to the ethanol, so that meant the atom economy increased; many did correctly point out that it increased to 100%. However, a sizeable number thought that question was asking about the atom economy of just carbon dioxide and not in combination with ethanol.

(ii) Explain the effect on the atom economy of this reaction if the carbon dioxide produced was used to make fizzy drinks.

(2)

It would not have changed as you are trying to produce ethanol not carbon dioxide

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Examiner Comments

Quite a few candidates misunderstood the question as this example shows.

This scored 0.

(ii) Explain the effect on the atom economy of this reaction if the carbon dioxide produced was used to make fizzy drinks.

(2)

The atomy eccnomy would increase because the ratio of desired product to all product would be higher

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Examiner Comments

This candidate identified that the atom economy would increase but has not said why it would increase. So this just scored 1 mark.

(ii) Explain the effect on the atom economy of this reaction if the carbon dioxide produced was used to make fizzy drinks.

(2)

The atom economy would become 100% because all the products would be desired.

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Examiner Comments

Most candidates had realised that with carbon dioxide being used to make fizzy drinks, both products would then be useful, and as this candidate pointed out, it would rise to 100%.

This answer scored 2 marks.

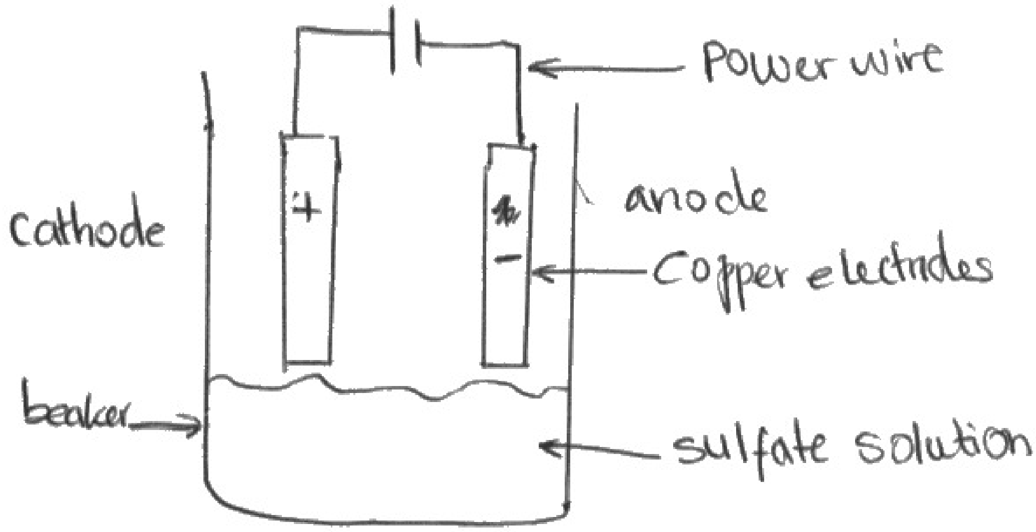
Question 5 (a)

This question asked for a fairly straightforward diagram of a cell that could be used to electrolyse copper sulfate solution using copper electrodes. For some candidates, labelling seems to be optional even though it was asked for. However the majority of the candidates could produce a diagram that deserved full marks. The most common errors here included not having the electrodes in the electrolyte, the electrodes connected to one outlet from a power pack and an electrolysis cell without a power source.

5 When copper sulfate solution is electrolysed using copper electrodes, the mass of each electrode changes.

(a) Draw a labelled diagram to show the apparatus that can be used to electrolyse copper sulfate solution using copper electrodes.

(2)



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Examiner Comments

Electrodes, which here were labelled the wrong way round, had to go into the electrolyte to score the 1st mark otherwise it would not work.

Electrodes connected to power supply scored the 2nd mark.

This scored just the second mark only.

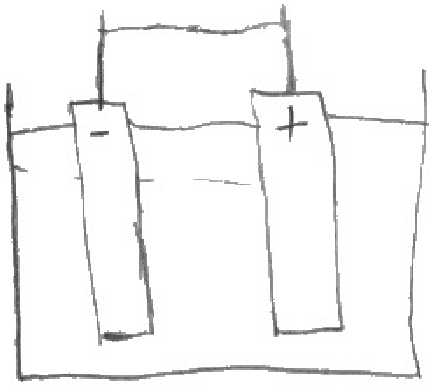
ResultsPlus
Examiner Tip

It would be useful if candidates had opportunities to practice drawing apparatus that could be used for experimental work.

5 When copper sulfate solution is electrolysed using copper electrodes, the mass of each electrode changes.

(a) Draw a labelled diagram to show the apparatus that can be used to electrolyse copper sulfate solution using copper electrodes.

(2)



ResultsPlus Examiner Comments

The candidate has drawn two electrodes in an electrolyte for the 1st marking point.

No power supply has been drawn, so the 2nd marking point could not be given. This diagram contained no labels. So even if it included a power supply, it couldn't score full marks.

This scored 1 mark.

Question 5 (b)

Many candidates understood the need to clean the electrodes using emery paper (or similar) to remove surface oxides or other material that could hinder efficient electrolysis of the copper sulfate solution. However, for some the extent of electrode preparation extended to just labelling them as anode and cathode. Some misunderstood the question and described how to treat the electrodes AFTER electrolysis by washing with distilled water and drying before finding their mass. Overall, many did not score on this question.

(b) Before the electrolysis is carried out, the mass of each electrode is determined.

Explain what should be done to the copper electrodes before their masses are determined.

(2)

They should be cleaned by sanding down the surface and washing off with distilled water along with alcohol. This is to obtain an accurate mass as it removes oxidised copper

ResultsPlus
Examiner Comments

This is a great answer – it's made the point about using an abrasive material on the surface of the electrode and why it should be done – to remove any oxidised copper.

This scored 2 marks.

(b) Before the electrolysis is carried out, the mass of each electrode is determined.

Explain what should be done to the copper electrodes before their masses are determined.

(2)

They should be dried so that any extra solution doesn't affect ~~their mass~~ the mass measured.

ResultsPlus
Examiner Comments

Reading the candidate's answer, it looks like they had misunderstood the question. The answer given is that for a different question about what should be done to the electrodes AFTER electrolysis before determining the masses.

This scored 0.

ResultsPlus
Examiner Tip

Candidates should read the whole question and not just the command line.

Question 5 (c)(i)

For full marks, candidates needed to explain why there was a mass loss at the anode – copper atoms from the anode being oxidised (and going into the solution); why there was a mass increase at the electrode – copper ions that have moved through the solution being reduced at the cathode by accepting electrons. Most candidates made a good attempt at this question, but often their answers lacked some detail that resulted in not being able to obtain full marks. Often the point about the cations moving through the solution to the cathode was missing. Other errors included writing about anions being oxidised at the anode which caused the mass loss; some thought it was the anode mass loss which was due to electrons lost and cathode mass gain due to electrons gained. The more able students offered half equations for what happened at the electrodes, which generally were well written.

(i) **Explain, in terms of ions, the changes in mass of the two electrodes shown in the results in Figure 4.**

(3)

Anode - the anode is the site of oxidation where ~~ions~~ neutral copper atoms loose electrons to form cations, these positively charged cations are attracted to the negative cathode as opposites attract. $2Cu \rightarrow Cu^{2+} + 2e^-$. reducing its mass

Cathode - Positive copper ions are attracted to the negative cathode. Once in contact, the ions are reduced and therefore gain electrons to form neutral copper ~~ions~~ atoms which bond to the cathode increasing its mass. $Cu^{2+} + 2e^- \rightarrow 2Cu$

ResultsPlus
Examiner Comments

This answer had everything detailed at both electrodes as well as the movement of the cations through the solution to the cathode.

This answer scored on all three marking points.

(i) Explain, in terms of ions, the changes in mass of the two electrodes shown in the results in Figure 4.

(3)

The anode lost mass because copper atoms were oxidised to create Cu^{2+} ions in the electrolyte, these ~~[illegible]~~ ~~[illegible]~~ positive ions were then attracted to the negative cathode where they were reduced ($Cu^{2+} + 2e^- \rightarrow Cu$) to form copper metal on the cathode therefore increasing its weight.

ResultsPlus
Examiner Comments

This was another good answer explaining what happened to the anode, in the solution and at the cathode. The use of half equations in this type of question does help the candidate to explain things.

This scored 3 marks.

Question 5 (c)(ii)

Most candidates suggested just increasing the current or increasing the concentration of the copper sulfate solution and scored just 1 mark. However, the more able candidates saw the significance of the increase of mass as 2.34 g being 3 times the increase of the change in mass of the cathode, and these candidates scored full marks on this item with answers such as 'Use three times the current', or similar.

(ii) The electrolysis was repeated using another pair of copper electrodes of the same masses.

Explain a change that could be made to the electrolysis experiment to cause the mass of the cathode to increase by 2.34 g in 10 minutes.

(2)

Make the concentration of the copper sulfate solution stronger so that the reactions happen quicker.

ResultsPlus
Examiner Comments

The candidate has not given the factor (3x) by which the concentration has to be increased so only scored the 1 mark for this answer.

(ii) The electrolysis was repeated using another pair of copper electrodes of the same masses.

Explain a change that could be made to the electrolysis experiment to cause the mass of the cathode to increase by 2.34 g in 10 minutes.

(2)

$2.34 \div 0.78 = 3$

Increase the power by 3 times
$(\times 3)$

ResultsPlus
Examiner Comments

The calculation to show a factor of 3 gained the first mark. Increasing the power by 3 scored the second mark. The increase of mass by 2.34 g was overlooked by most candidates who scored marks on this question – most just gave the answer of increase the current, increase the voltage or increase the concentration of the solution.

2 marks.

Question 6 (a)

The greater majority of the candidates knew that aluminium is higher in the reactivity series and most of those went on to state that either aluminium needed a large amount of energy to extract it or that it could not be displaced by carbon. Another way candidates scored marks was to go down the route of aluminium being more reactive than carbon, but those who chose to say that aluminium was more reactive than hydrogen or a metal such as copper did not score as they were not appreciating why electrolysis was needed in the extraction process.

(a) Aluminium is extracted from its ore by electrolysis.

Explain why this method is used to extract aluminium from its ore.

(2)

Electrolysis is used, as aluminium is more reactive than copper therefore reduction cannot be used in this case. Copper cannot make aluminium lose oxygen.

ResultsPlus
Examiner Comments

Several candidates spoilt their answers as in this example where they wrote about aluminium being more reactive than copper as a reason for electrolysis to be used to extract aluminium. Unfortunately this did not score as it did not explain the need for electrolysis.

(a) Aluminium is extracted from its ore by electrolysis.

Explain why this method is used to extract aluminium from its ore.

(2)

Aluminium is more reactive than carbon so cannot be displaced by carbon. ~~Istead~~ Instead aluminium must be separated from its ore by using electricity ~~and the~~ as it is very reactive. ~~both a~~ High amounts of energy is therefore needed to extract aluminium from its ore.

ResultsPlus
Examiner Comments

Aluminium is more reactive than carbon (or above carbon in the reactivity series) allowed for 1st mark as an alternative for the point about aluminium being very reactive. Mention of high amounts of energy needed scored the second mark. The answer went on to explain that aluminium cannot be displaced by carbon – this was an alternative acceptable answer for the second mark but this had already been scored.

2 marks

Question 6 (b)(i)

Most candidates scored a mark for knowing that a redox reaction involved oxidation and reduction; sometimes this was seen when they stated what was oxidised and what was reduced in the reaction. Although most knew that magnesium was oxidised in the reaction when it lost 2 electrons. To get the mark for identifying the reduction part of the reaction, candidates needed to state that it was the titanium ion or Ti^{4+}. Titanium alone here was not enough given that titanium was a product of the reaction. A significant number attempted this question by describing the redox as loss and gain of chlorine.

(b) (i) One step in the extraction of titanium metal involves the displacement reaction between titanium chloride, $TiCl_4$, and magnesium.

$$TiCl_4 + 2Mg \rightarrow Ti + 2MgCl_2$$

This equation can be simplified as

$$Ti^{4+} + 2Mg \rightarrow Ti + 2Mg^{2+}$$

Explain why this displacement reaction can be described as a redox reaction.

(3)

Because a metal magnesium is being oxidised losing electrons to titanium which is reduced gaining electrons. $2Mg \rightarrow 2Mg^{2+} + 4e^-$

$Ti^{4+} + 4e^- \rightarrow Ti$

ResultsPlus
Examiner Comments

This answer explained that a redox reaction involved both oxidation and reduction which scored the first mark. Although the candidate had not specified titanium ions being reduced in the 2nd line, this was clarified by the second half equation and that together with the explanation about magnesium scored the other two marks.

This scored 3 marks.

(b) (i) One step in the extraction of titanium metal involves the displacement reaction between titanium chloride, $TiCl_4$, and magnesium.

$$TiCl_4 + 2Mg \rightarrow Ti + 2MgCl_2$$

This equation can be simplified as

$$Ti^{4+} + 2Mg \rightarrow Ti + 2Mg^{2+}$$

OILRIG

Explain why this displacement reaction can be described as a redox reaction.

(3)

As there has been both reduction and gaining of electrons. The magnesium has been reduced because it has gained 2+ ~~ions~~ electrons but the titanium has been oxidised as it ~~have~~ has lost electrons.

ResultsPlus
Examiner Comments

Mention of reduction and oxidation here scored the first mark. Many candidates confused what was going on in the ionic equation with the explanation about oxidation and reduction, with many, as here, getting the processes the wrong way round.

So, this answer scored just 1 mark for reduction and oxidation both taking place.

Question 6 (c)

Although most candidates gave the disadvantage of phytoextraction as being slow or it took a long time to grow the plants, many answered this by saying that when burning the plants, carbon dioxide was evolved without taking into consideration that carbon dioxide was taken in by the plants when they were growing. A significant number of candidates still do not read questions carefully as was seen by those who just stated that it could be used to extract metals from low-grade ores, which appeared in the stem of the question and is not a disadvantage of the process.

(c) Phytoextraction is an alternative biological method that can be used to extract metals from very low-grade ores.

Give **one** disadvantage of phytoextraction as a method of extraction of metals.

(1)

the plant has to be burned to release the extracted metal and this can release green house gases

ResultsPlus
Examiner Comments

Greenhouse gases is equivalent to carbon dioxide and so were ignored. They are not toxic gases in this context.

This answer scored 0.

(c) Phytoextraction is an alternative biological method that can be used to extract metals from very low-grade ores.

Give **one** disadvantage of phytoextraction as a method of extraction of metals.

(1)

It allows efficient extraction of low grade ores

ResultsPlus
Examiner Comments

This answer is possibly true but it was not answering the question so no mark awarded as this would be an advantage.

(c) Phytoextraction is an alternative biological method that can be used to extract metals from very low-grade ores.

Give **one** disadvantage of phytoextraction as a method of extraction of metals.

(1)

It takes longer than the other methods of extraction.

ResultsPlus Examiner Comments

The growth of plants used to extract metals by phytoextraction is a process that takes a long time which is a disadvantage of the method so 1 mark was awarded.

Question 6 (d)

Many candidates do find trying to describe a simple method quite difficult, with just half the candidates scoring at least one mark. Here we were looking for methods such as heating with carbon to obtain the copper from copper oxide. Some suggested using a more reactive metal, which was fine but omitted to say how the copper would be separated from the other metal oxide. However, most candidates opted for just heating the copper oxide alone to obtain the copper. Another error frequently seen was trying to dissolve the copper oxide in water and electrolysing the solution.

(d) Copper is low down in the reactivity series and can be obtained from copper oxide.

Devise a simple method to obtain a sample of copper from copper oxide in the laboratory.

(2)

Combust both the copper oxide together along with a sample of carbon such as coal. This will cause the carbon to displace the copper from its compound forming ~~that~~ carbon dioxide and copper.

ResultsPlus Examiner Comments

1 mark was awarded for the copper oxide and carbon together. The 2nd mark was not awarded as 'combust' is not the same as heat strongly. We were looking for the heating of the copper oxide with carbon in this situation.

1 mark awarded overall.

(d) Copper is low down in the reactivity series and can be obtained from copper oxide.

Devise a simple method to obtain a sample of copper from copper oxide in the laboratory.

(2)

The copper oxide should be weighed. ~~used~~ A Bunsen burner should be set up with a heat-proof mat under it and a tripod stand over it. A mesh sheet should be put on top of the tripod stand. The copper oxide should be placed in a crucible (the crucible on the mesh sheet) and heated with a Bunsen burner until fully reacted (and then weighed again).

ResultsPlus
Examiner Comments

Heating the copper alone as described in this answer is not sufficient to cause the copper oxide to decompose into its elements.

This scored 0 marks.

★ (d) Copper is low down in the reactivity series and can be obtained from copper oxide.

Devise a simple method to obtain a sample of copper from copper oxide in the laboratory.

(2)

Copper oxide can be heated & with carbon to reduce copper. Use a bunsen burner to heat the copper oxide ~~which will~~ with carbon in a crucible. The carbon will displace ~~carbon~~ copper to form carbon dioxide and will leave pure copper. Leave the copper to cool and allow CO_2 to escape to obtain a pure sample.

ResultsPlus
Examiner Comments

Heating the copper oxide with carbon would produce copper and carbon dioxide. The carbon dioxide would dissipate into the atmosphere and not contaminate the copper. So this answer was given 2 marks – for mixing with carbon and 1 for heating the mixture.

Question 7 (a)

The correct colour change of methyl orange in this titration was not very well known. Of those who had the correct colours, often they were the wrong way round going from orange to yellow.

Question 7 (b)

Overall, the number who complete the balanced equation correctly was quite disappointing. Only a minority could give a correct formula for ammonium sulfate and then balance the equation. The most common formulae given were NH_4SO_4 and $(NH_3)_2SO_4$ (which meant that hydrogen also appeared as a product). Many candidates also added other products to the right hand side; these included SO_2 and H_2O.

(b) When the ammonia solution was neutralised by the dilute sulfuric acid, a solution of ammonium sulfate was formed.

Complete the balanced equation for the reaction between ammonia solution and sulfuric acid.

(2)

$$NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4 + H_2$$

N = 1

ResultsPlus
Examiner Comments

Even though the correct formula for ammonium sulfate was given, the candidate has also written H_2 on the products line, so the first marking point could not be given.

(b) When the ammonia solution was neutralised by the dilute sulfuric acid, a solution of ammonium sulfate was formed.

Complete the balanced equation for the reaction between ammonia solution and sulfuric acid.

(2)

$$2\ NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$$

ResultsPlus
Examiner Comments

Only a few candidates could complete the balanced equation with the correct formula of ammonium sulphate and balance for the ammonia.

ResultsPlus
Examiner Tip

Practice balancing equations.

Question 7 (c)

It appears that many candidates had not read the opening paragraph to this question. In it they were told that the titration was repeated to obtain a mean volume of acid and that the volumes of the two solutions were measured accurately. Equally there were many candidates that had not understood the first five words of the command line: 'Explain **two** other practical steps ...'. Many answers were seen suggesting that the titration should be repeated or somehow the volumes of the solutions should be measured with a burette / pipette / measuring cylinder to get an accurate volume of a solution. Some also gave three practical steps; in these instances we do not mark 'the best two', but if two are correct and one incorrect, then only one will score. This is standard practice.

(c) The titration was repeated to obtain a mean volume of dilute sulfuric acid required to neutralise the 25.0 cm^3 of ammonia solution.
The volumes of the two solutions were measured accurately.

Explain **two** other practical steps that should be used in the titration to ensure that an accurate titre volume is obtained.

(4)

1 ~~Use a a~~ Ensure that the dilute sulfuric acid is only added drop by drop to make sure an accurate value is obtained and the solution does not turn acidic

2 Place the conical flask on a white tile so the colour change of the methyl orange indicator is clearer to observe.

ResultsPlus
Examiner Comments

When candidates were wanting to add acid drop by drop, we were looking for an indication that it was just near the end point and not through the whole titration. The reason, 'to stop it turning acidic' was fine for the reason. This practical step scored 1 mark.

The candidate has correctly explained why a white tile should be used, and scored 2 marks.

Overall, this scored 3 marks.

(c) The titration was repeated to obtain a mean volume of dilute sulfuric acid required to neutralise the 25.0 cm^3 of ammonia solution.
The volumes of the two solutions were measured accurately.

Explain **two** other practical steps that should be used in the titration to ensure that an accurate titre volume is obtained.

(4)

1 Use a burette so that the drips are one at a time and all equal.

2 Swill the flask after every drop to make sure the colour has completely changed.

ResultsPlus
Examiner Comments

'Drips are one at a time' did not achieve a mark as 'near end point' was not mentioned.

The second practical step and reason were fine for two marks.

Question 7 (d)

In general, candidates do find describing experimental techniques at this level to be challenging. We are required to include the assessment criteria AO3-3 which covers developing experimental procedures. This question was poorly scored overall. Many of the candidates could not describe the basic three steps involved: heating the solution to concentrate it, allowing it to cool and crystallise, and finally drying the crystals in a suitable way. Often answers included that the solution should be heated until all the water had gone, or that the solution should be filtered and the crystals on the filter paper then dried. Such was the way candidates answered this that it was sometimes difficult to see what could score a mark. A significant number of candidates wrote ‘use crystallisation’ without a basic plan.

(d) The mean volume of dilute sulfuric acid required to neutralise the ammonia solution was determined from the results of the titration.

This volume of dilute sulfuric acid was added to 25.0 cm^3 of ammonia solution in a conical flask.

Devise a plan to produce a sample of dry ammonium sulfate from the contents of the conical flask.

(3)

Pour the contents of the conical flask into a heat resistant dish and heat using a bunsen burner. ~~Allow~~ Leave ~~for~~ to allow water to evaporate and then pour the contents into a petri dish. Leave for a few days to allow ~~[illegible]~~ the sample to crystallise fully. ~~Then pat dry with paper if needed~~

(Total for Question 7 = 11 marks)

ResultsPlus
Examiner Comments

This scored 2 marks – 1 for heating the solution and 1 for allowing the now concentrated solution to crystallise.

There were candidates who missed the last point to produce a dry sample; this could be easily done by removing the crystals and then pat drying them with a filter paper.

(d) The mean volume of dilute sulfuric acid required to neutralise the ammonia solution was determined from the results of the titration.

This volume of dilute sulfuric acid was added to $25.0\,cm^3$ of ammonia solution in a conical flask.

Devise a plan to produce a sample of dry ammonium sulfate from the contents of the conical flask.

(3)

• When the acid has neutralised the solution, water is also formed.
• To get rid of the water, heat the mixture gently until most of the water has been evaporated.
• Filter the ammonia sulfate after and the filtrates should end up with dry ammonium sulfate.

ResultsPlus
Examiner Comments

This scored just 1 mark for heating the mixture gently until most of the water had evaporated.

Many candidates seemed to think that the ammonium sulfate was either a solid that could be removed by filtration and then dried, or it somehow precipitated and then could be filtered out and then dried.

Question 8 (b)

A few candidates linked the structure of graphene to a single layer of graphite and gave a good description of the number of bonds each carbon atom forms to then reason why it was a good conductor of electricity. However, several didn't stop there and needlessly wrote about the properties of graphite. The most common marking point seen was for delocalised electrons, the least seen was realising either that there were four electrons available for bonding on each carbon atom or that as a result each carbon atom bonding to three other carbon atoms, there would be one electron remaining unbonded.

Explain why graphene will be a good conductor of an electric current.

(3)

As the each carbon atom is bonded with 3 other atoms allowing easy transportation of electrons between each atom

ResultsPlus
Examiner Comments

In this answer there seemed to be no idea of 4 outer shell electrons on each carbon atom but there was the idea of bonds with 3 other carbon atoms which scored 1 mark. 'easy transportation of electrons' was not sufficient for unbonded electrons being free to move so this did not score.

Overall, this scored 1 mark.

Explain why graphene will be a good conductor of an electric current.

(3)

Graphene is a good conductor of electricity because each of it's carbon bonds covalently bond to 3 other carbon leaving one delocalised electron which is charged therefore meaning it can conduct electricity well and it can absorb the electrical energy.

ResultsPlus
Examiner Comments

This scored all 3 marks.

1 for bonding to 3 other carbon atoms

1 for the remaining electron

1 for those remaining electrons being delocalised.

Explain why graphene will be a good conductor of an electric current.

(3)

because graphene contains carbon atoms next are chemically bonded to only three other carbons so it means there is a spare unused electron that is not bonded so this electron can delocalise and is free to move and carry a ~~carry a~~ charge and therefore ~~conduct~~ ~~charge~~ causes a current so the graphene will conduct electricity when

ResultsPlus
Examiner Comments

This scored all 3 marks:

1 mark for one unused electron

1 mark for bonding to 3 other carbon atoms

1 mark for delocalised electrons or electrons free to move.

Question 8 (c)

Nearly half the candidates could either describe the structure type of potassium bromide or the type of bonding and then go on to say that a large amount of energy was needed to break the strong forces between the ions that caused the substance to have a high melting point, so this showed that this link was well understood. However, there was a significant number who spoilt their answer by using such terms as 'molecules of potassium bromide' or 'intermolecular forces between the ions'. A minority did refer to the bonding between the ions as 'covalent'.

Explain why potassium chloride has a high melting point.

(2)

potassium chloride ions are held together by very strong ionic bonds which have very strong electrostatic forces of attraction between oppositely charged ions acting in all directions meaning it needs lots of energy to break the bonds, so requires high temperature

ResultsPlus
Examiner Comments

An excellent answer that scored 2 marks. It detailed the structure and type of bonding and then went on to state that a large amount of energy was needed to break the bonds.

Explain why potassium chloride has a high melting point.

(2)

Potassium chloride is a compound with different sized atoms making it hard to melt.

ResultsPlus
Examiner Comments

Quite a few candidates wrote a similar answer to this focussing on the different sizes, but made it worse by describing the particles as atoms rather than as ions. This answer contained nothing creditworthy.

Explain why potassium chloride has a high melting point.

(2)

Pottassium Chloride is an ionic Compound which has strong intermolecular forces between K^+ ions and Cl^- ions, which require large amount of thermal energy to break to result in melting.

ResultsPlus
Examiner Comments

The incorrect use of 'intermolecular' stopped the first mark being given. However, the second mark was given for saying that a large amount of energy was needed to break the bonds.

Question 8 (d)

Overall, this 6-mark question performed well, with many candidates showing their knowledge of the models shown by the representation of a methane molecule and a very good distribution of marks was obtained skewed towards the top end. Although most could write in quite good detail about structures A – C, the 3D aspect of structures D and E appeared to be less well known.

Here a level 1 answer just required simple statements about some of the models or a description of one of the models. The molecular formula and dot and cross representations provided a straightforward way for candidates to score marks.

A level 3 answer required candidates to describe most of the models along with their limitations. However, candidates did find identifying limitations to be a more difficult aspect of this question.

Describe what information can be obtained from each representation including the limitations of these representations of methane.

(6)

All 5 representations show the molecular formula for methene. B, C and D all show single bonds, while B also shows they are covelant. D and E show what the molecule would actually look like. B shows the sharing of electrons. D and E may be unrecognisable without a key for the different spheres. B also shows the electron configuration of both Carbon and Hydrogen atoms.

ResultsPlus
Examiner Comments

This was a level 2 answer and given 4 marks.

Although all 5 structures had been described, there wasn't any recognition of 2D and 3D structures which limited the description particularly in structures C, D and E. The description didn't give many limitations, so this was a good Level 2 answer.

Describe what information can be obtained from each representation including the limitations of these representations of methane.

(6)

CH_4 shows the components but not the structure, B shows the outer shells, but, like C, is 2D so not the true structure, D & E are 3D, so more accurate, but D uses unrealistic rods. C is like B exce

ResultsPlus Examiner Comments

This was a level 1 answer and given 2 marks.

The description just contained simple statements for most of the structures, but lacked any detail about them or their limitations needed to access the higher levels.

Question 9 (a)(i)

This question was very straightforward and the majority of candidates scored 2 marks. A few had metals W and Y the wrong way round and so only scored 1 mark.

Question 9 (a)(ii)

For most of the candidates this was a very challenging question and tested their ability to interpret the information they were given. In the first part of the question, they were told that metal Y reacted with an excess of dilute hydrochloric acid and all the metal had reacted after three. Here they were told that with an excess of dilute sulfuric acid bubbles formed quickly but soon the reaction stopped and most of the metal remained. Only a few candidates realised that the metal sulfate that formed was coating the metal and prevented further reaction. Most candidates offered the idea of a limiting reactant or that not enough acid was added, or that the acid was too dilute which did not score.

Explain why the reaction between metal Y and excess dilute sulfuric acid stopped even though there was solid metal Y left.

(2)

because metal Y was relatively unreactive so once outside of metal reacted it didn't react any further

ResultsPlus
Examiner Comments

Answers such as this were seen very often. Earlier in Q09, it was established that metal Y was quite reactive as given by the observations of its reaction with dilute hydrochloric acid. This answer didn't really establish why the reaction stopped when there was still some left.

This scored 0 marks.

Explain why the reaction between metal **Y** and excess dilute sulfuric acid stopped even though there was solid metal **Y** left.

(2)

Metal Y is likely to have formed a layer of metal sulfate around the metal so that the sulfuric acid cannot access the metal and cannot react.

ResultsPlus
Examiner Comments

This candidate referred to the formation of a layer of metal sulfate which was credited for the first mark. 'The sulfuric acid cannot access the metal' is the idea of preventing reaction and scored the second mark.

Few candidates had rationalised it in this way. This answer scored 2 marks.

Question 9 (a)(iii)

Many candidates confused the idea of 'weak' with 'dilute', or simply said that a weak acid had a fairly high pH and did not answer the question 'Explain the meaning of the term **weak acid**.'

A good number did mention that the acid was partially or not completely ionised in solution but missed the point about it being an acid which needed some reference to the concentration of H^+ ions then being lower than expected.

Explain the meaning of the term **weak acid**.

(2)

A weak acid only partially dissociates into ions when dissolved ~~into~~ in water. Therefore there is a low concentration of hydrogen ions.

ResultsPlus
Examiner Comments

This was given 2 marks.

The acid 'partially dissociates' into ions scored the 1st mark and the 2nd mark was given for 'low concentration of hydrogen ions'.

Explain the meaning of the term **weak acid**.

(2)

Weak acids are not fully dissociating and have a higher pH than strong acids.

ResultsPlus
Examiner Comments

This scored 1 mark.

1 mark was given for the point about the acid 'not fully dissociated'. Many candidates made reference to a higher pH than strong acids but they didn't make it clear that it wasn't down to dilution factors but that fewer H^+ were present because of the incomplete dissociation of the acid in water.

Question 9 (b)

In such a tricky calculation, most candidates were able to score marks. Calculating the relative mass of aluminium sulfate and then calculating the number of moles of that substance was seen on most candidates' work. From this stage, the most popular answer seen was to multiply the number of moles of aluminium sulfate by the Avogadro constant, scoring 3 marks with an answer of 9.03×10^{21}, but only a few scored full marks by taking into account that there were 17 atoms combined together in the formula $Al_2(SO_4)_3$.

(b) The formula of aluminium sulfate is $Al_2(SO_4)_3$.

Calculate the total number of atoms that combine to form 5.13 g of aluminium sulfate.

(relative atomic masses: O = 16.0, Al = 27.0, S = 32.0
Avogadro number = 6.02×10^{23})

(4)

moles = $\frac{mass}{M_r}$ $27 \times 2 = 54$ $32 + (4 \times 16) = 96$

$96 \times 3 = 288$

$54 + 288 = 342$

moles = $\frac{5.13}{342} = 0.015$

$0.015 \times 6.02 \times 10^{23} = 9.03 \times 10^{21}$

number of atoms = 9.03×10^{21}

ResultsPlus
Examiner Comments

This answer was commonly seen and was given 3 marks:

The first mark was given for the correct calculation of M_r of aluminium sulfate.

The second mark was given for the calculation of the number of moles of aluminium sulfate.

The third mark was given for the multiplication of the number of moles x 6.02×10^{23}.

(b) The formula of aluminium sulfate is $Al_2(SO_4)_3$.

Calculate the total number of atoms that combine to form 5.13 g of aluminium sulfate.

(relative atomic masses: O = 16.0, Al = 27.0, S = 32.0
Avogadro number = 6.02×10^{23})

(4)

$\frac{5.13}{54+3(32+4(16))}$ = 0.015 mol of $Al_2(SO_4)_3$

$0.015 \times (2+3(5)) = 0.255$ = atoms in 0.015 ~~one~~ mol of $Al_2(SO_4)_3$

$0.255 \times 6.02 \times 10^{23} = 1.5351 \times 10^{23}$

number of atoms = 1.5351×10^{23}

ResultsPlus
Examiner Comments

This scored all 4 marks. The 4th mark here was for the inclusion of the number of atoms (17) that were combined in the formula of aluminium sulfate in the calculation. This calculation also had the bonus of being easy to follow.

(b) The formula of aluminium sulfate is $Al_2(SO_4)_3$. 17 atoms altogether

Calculate the total number of atoms that combine to form 5.13 g of aluminium sulfate.

(relative atomic masses: O = 16.0, Al = 27.0, S = 32.0
Avogadro number = 6.02×10^{23})

(4)

(27×2)+(32×3)+(16×7)= 262 → mass of 1 mole

$\frac{5.13}{262}$ = 0.01958015267 moles

0.0196 × Avogadro = $1.17872519 1\times10^{22}$ molecules

Answer × 17 = 2.003832824×10^{23} atoms

= 2.004×10^{23}

number of atoms = 2.004×10^{23}

ResultsPlus
Examiner Comments

Sometimes the formula mass had been incorrectly calculated as in this example. Error carried forward in the subsequent steps then resulted in 3 marks being given.

1 mark was given for calculating the number of moles (ECF from M_r) on the second line.

1 mark was given for number of moles x Avogadro constant on the 3rd line (ECF)

1 mark was given multiplying the number of 'molecules' x number of atoms in the formula of the compound (ECF from Mr). We ignored the use of 'molecules' on the 3rd line as this erroneous term did not interfere with the calculation.

Question 9 (c)

It was pleasing to see how well many candidates tackled this question to conclude that Equation 2 represented the reaction that was taking place. There was no single method of calculation, but several ways of dealing with the calculation were seen. The most obvious was to calculate the number of moles of each element and then obtain the simplest whole number ration which then showed Equation 2. The other common way seen was to use the mass of iron to calculate the mass of lead produced using at least one of the reaction equations to show that it was Equation 2. Just stating Equation 2 without any justification scored no marks.

(c) Iron is more reactive than lead.
Iron reacts with lead nitrate solution to form solid lead.
Two possible balanced equations for the reaction are

Equation **1** $Fe + Pb(NO_3)_2 \rightarrow Fe(NO_3)_2 + Pb$

Equation **2** $2Fe + 3Pb(NO_3)_2 \rightarrow 2Fe(NO_3)_3 + 3Pb$

In one experiment, it was found that 4.48 g of iron reacted with excess lead nitrate solution to form 24.84 g of lead.

Carry out a calculation, using the information above, to show which equation represents the reaction taking place.

(relative atomic masses: Fe = 56.0, Pb = 207)

(3)

4.48 ÷ 56 = 0.08 mol 24.84 ÷ 207 = 0.12

0.08 : 0.12 = 2 : 3

Reaction 2 is taking place because the ~~moles on~~ 2 moles of iron are reacting to form 3 moles of lead.

ResultsPlus
Examiner Comments

The number of moles of iron and of lead were both calculated correctly. This was followed by working out the simplest whole number ratio which then led to the conclusion that equation 2 represented the reaction that took place.

This scored 3 marks.

(c) Iron is more reactive than lead.
Iron reacts with lead nitrate solution to form solid lead.
Two possible balanced equations for the reaction are

Equation **1** $Fe + Pb(NO_3)_2 \rightarrow Fe(NO_3)_2 + Pb$

Equation **2** $2Fe + 3Pb(NO_3)_2 \rightarrow 2Fe(NO_3)_3 + 3Pb$

In one experiment, it was found that 4.48 g of iron reacted with excess lead nitrate solution to form 24.84 g of lead.

Carry out a calculation, using the information above, to show which equation represents the reaction taking place.

(relative atomic masses: Fe = 56.0, Pb = 207)

(3)

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

$\frac{4.48}{56} = 0.08 \xrightarrow{1:1} 0.08$ mol Pb

$RFM \times n = m$ $0.08 \times 207 = 16.56$.

$\frac{4.48}{56} = 0.08 \xrightarrow{2:3} 0.12$ mol Pb

$0.12 \times 207 = 24.84g$

Therefore it is equation 2.

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Examiner Comments

In this approach, the candidate had used both equations to calculate the mass of lead produced from 4.48 g of iron. From this the candidate could see that equation 2 was the one representing the reaction taking place.

This too scored 3 marks.

(c) Iron is more reactive than lead.
Iron reacts with lead nitrate solution to form solid lead.
Two possible balanced equations for the reaction are

Equation **1** $Fe + Pb(NO_3)_2 \rightarrow Fe(NO_3)_2 + Pb$

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In one experiment, it was found that 4.48 g of iron reacted with excess lead nitrate solution to form 24.84 g of lead.

Carry out a calculation, using the information above, to show which equation represents the reaction taking place.

(relative atomic masses: Fe = 56.0, Pb = 207)

(3)

56 + 207 → 56 + 207 2(56) + 3(207) → 2(56) + 3(207)

263 → 263 112 + 621 → 112 + 621

733 → 733

Moles = mass/RMM = 4.48/56 = 0.08 Moles = mass/RMM = 4.48/112 = 0.04

= 24.84/207 = 0.12 = 24.84/621 = 0.04

(Total for Question 9 = 13 marks)

0.08/0.08 + 0.12/0.08 Equation 2 0.04/0.04 + 0.04/0.04

1 : 1.5 1 : 1

(1) ✗ (2) ✓

ResultsPlus
Examiner Comments

Here the candidate carried out 2 calculations – 1 based on equation 1 and the other based on equation 2. In this case the number of moles of each metal was calculated based on its relative atomic mass and the number of it shown in the equation.

The candidate ruled out equation 1. They could have stopped here and still scored full marks. However, it looks like they decided to check their work. They have multiplied the relative atomic mass of iron by 2 and multiplied the relative atomic mass of lead by 3 and calculated number of moles based on these correctly as 0.04 and 0.04 from equation 2. Therefore it was equation 2. This showed there was more than one method they can use to determine the stoichiometric equation for a reaction.

This answer also scored 3 marks.

Question 10 (a)(i)

About a quarter of the candidates understood what was meant by 'dynamic' in dynamic equilibrium. Some just described a reversible reaction by saying dynamic meant it the reaction went both ways. However, several candidates just gave a general meaning of the word dynamic which didn't score the mark.

10 When hydrogen is removed from an alkane, an alkene is formed.

This is an example of a dehydrogenation reaction.

(a) Under certain conditions the dehydrogenation of propane forms propene and a dynamic equilibrium is reached.

(i) State what is meant by dynamic in this context.

(1)

The forwards reaction is happening at the same rate as the backwards reaction.

ResultsPlus
Examiner Comments

The forward and back reactions are happening at the same rate implies that they are occurring at the same time.

This scored 1 mark

10 When hydrogen is removed from an alkane, an alkene is formed.

This is an example of a dehydrogenation reaction.

(a) Under certain conditions the dehydrogenation of propane forms propene and a dynamic equilibrium is reached.

(i) State what is meant by dynamic in this context.

(1)

propene breaks down to form propene + hydrogen at the same rate they bond to form propene

ResultsPlus
Examiner Comments

This looks correct but they have said to form propene on the last line instead of propane and so simple error stopped the mark from being awarded.

0 marks

ResultsPlus
Examiner Tip

Candidates do need to take care when writing the names of various substances – an incorrect letter can make a huge difference.

Question 10 (a)(ii)

Most candidates knew that they would have to write about the effect of temperature, pressure and the presence of a catalyst to answer this question in its entirety. Most candidates could tackle the idea that a high temperature would be needed to achieve a high yield of propene since the reaction was endothermic and that it would also increase the rate of attainment of equilibrium. Several candidates struggled with the pressure required to maximise yield and rate production. The more astute candidate realised that since the left side of the equation contained just one mole of gas and the right two moles of gas, a low pressure would favour the yield but would also lower the rate of production. The effect of a catalyst on the equilibrium generally worked well in this question.

*(ii) The equation for this equilibrium reaction is

→ endo

$$C_3H_8(g) \rightleftharpoons C_3H_6(g) + H_2(g)$$

propane   propene

The forward reaction takes in heat energy and is endothermic.
A manufacturer produces large quantities of propene using this equilibrium reaction.

Suggest, with explanations, suitable conditions that the manufacturer could use to maximise the yield and rate of production of propene from propane.

(6)

Firstly the manufacturer could ~~incr~~ decrease the ~~pres~~ temperature so more propene ~~wol~~ ~~would~~ ~~be~~ would be produced as the equilibrium shifts to the products side to increase the temperature

Secondly the manufacturer ~~could~~ could decrease the ~~pres~~ pressure so more propene is made as ~~the~~ there are more ~~mol~~ ~~mole~~ molecules on the product ~~side~~ a side, so the equalibrium would shift to the product side to maintain pressure.

Thirdly the manufacturer could add a catalyst to speed up the reaction for both the products and the reactants

However the manufacturer must find a ~~comprise~~ comprimise between efficiency and money. For example, decreasing the presure is good but ~~up~~ it would cost a lot of money to maintain the pressure as ~~it~~ all the pipes and vessels need to be checked ~~regentaly~~ regerulary. Furthermore decreasing the ~~temp~~ ~~d~~ temperature is more efficient but if the manufacturer has a lot of customers, faster production is better than more efficient.

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Examiner Comments

Level 2 – 3 marks

In the first paragraph, decreasing the temperature does not shift equilibrium to the products side, so there was nothing here to credit. In the second paragraph, decreasing (or a low) pressure does favour the products side – effect on yield was given along with an explanation. Finally the effect of adding a catalyst does have a correct statement about increased rate.

Two factors were discussed, one with an explanation, so this scored 3 marks.

*(ii) The equation for this equilibrium reaction is

$$C_3H_8(g) \rightleftharpoons C_3H_6(g) + H_2(g)$$

propane   propene

The forward reaction takes in heat energy and is endothermic.
A manufacturer produces large quantities of propene using this equilibrium reaction.

Suggest, with explanations, suitable conditions that the manufacturer could use to maximise the yield and rate of production of propene from propane.

(6)

Endothermic reactions favour higher temperatures. Higher temperatures mean particles have more kinetic energy meaning there are more successfull collisions which increases rate of production of propene. Endothermic reactions also favour higher pressure. Higher pressure means there are more particles in a given volume resulting in more frequent successfull collisions which also increases rate of production. ~~However higher pressure and temperature will lower the yield~~ Higher pressure and temperature will increase rate of production. ~~but can lower the yield~~ To allow a higher yield to be obtained from lower temperatures, a catalyst can be used. This makes it less dangerous as ~~high~~ very high temperature and pressure ~~and~~ aren't required. Therefore, to maximise yield and rate, high temperature and high pressure can be used in the prescence of a catallyst.

ResultsPlus
Examiner Comments

Level 2 – 4 mark

Within this answer, use of higher temperature was discussed with an explanation based on collision theory for rate. There was also the use of higher pressure would increase the rate of production with an explanation based on collision theory. The effect of catalyst on yield was linked with the use of a lower temperature but did not take into account effect of equilibrium on yield of product by also favouring reactant side as well.

So two factors discussed with explanation of rate – 4 marks.

*(ii) The equation for this equilibrium reaction is

$$C_3H_8(g) \rightleftharpoons C_3H_6(g) + H_2(g)$$

propane   propene

The forward reaction takes in heat energy and is endothermic.
A manufacturer produces large quantities of propene using this equilibrium reaction.

Suggest, with explanations, suitable conditions that the manufacturer could use to maximise the yield and rate of production of propene from propane.

(6)

A comprimised temperature can be used because the reaction is endothermic and increased heat will benefit the backwards reaction however an increased heat also increased the rate of production So ~~ra~~ temperature should be moderatly high.

the reaction has ~~the~~ less usefull atoms on the forward reaction therefore an increase in pressure will increased the rate of

forward reaction and give you a higher yield and rate of production of propene.

ResultsPlus
Examiner Comments

Level 1 – 2 mark

The first part of the answer that is creditworthy is on line 5 – 'however an increased temperature also increases the rate of production'. Later on in the answer, the candidate wrote that increasing pressure increases the rate of reaction. These two simple statements keeps this in level 1, but is over two of the 3 conditions (temperature, pressure, presence of a catalyst) that gave it 2 marks.

Question 10 (b)

This should have been a straightforward Avogadro's law question where 1 mole of propane would form 1 mole of propene as shown by the equation. So 300 dm^3 of propane would form 300 dm^3 of propene. Many candidates tried a variety of different calculations leading to an incorrect answer.

Question 10 (c)

Candidates need to appreciate that in any calculation on an examination paper at this level, all the information they need will be given in the question. Many candidates incorrectly thought that they had to work out the relative formula masses of propane and propene and then to divide the volume of propane by its relative formula mass, which got them nowhere. These candidates didn't seem to know what to do with the volume of 1 mole of gas as given in the question.

Many candidates, however, calculated the number of moles of propane (and hence hydrogen) from its volume and the volume occupied by 1 mol of gas. Those that went on to calculate the mass of hydrogen in kilograms then had two further hurdles to get over. The first was to multiply the number of moles of hydrogen x relative formula mass of H_2 and the second was to divide the mass by 1000 to convert it into kilograms. Only a minority managed to cross both hurdles.

(c) 900 dm^3 of propane, measured at room temperature and pressure, were dehydrogenated to form propene.

$$C_3H_8(g) \rightleftharpoons C_3H_6(g) + H_2(g)$$

propane propene

Calculate the maximum mass, in kg, of hydrogen formed in this reaction.

(relative atomic mass: H = 1.0;
1 mol of any gas at room temperature and pressure occupies 24 dm^3)

(4)

900 dm^3 ÷ 24 = 37.5 mol of propane
1:1 ratio
37.5 mol of hydrogen
37.5 mol x 1 = 37.5 kg

900000 cm^3 ÷ 24 = 37500 mol

mass of hydrogen = 37.5 kg

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Examiner Comments

This answer was given 2 marks.

Correct calculation of the number of moles of propane was followed up with showing that the there was a 1:1 ratio, so the number of moles of hydrogen was the same. Up to here, 2 marks were scored. After that the relative atomic mass of hydrogen was used in place of relative formula mass and this was then followed by an incorrect assumption that the units would then be in kg.

(c) 900 dm^3 of propane, measured at room temperature and pressure, were dehydrogenated to form propene.

$$C_3H_8(g) \rightleftharpoons C_3H_6(g) + H_2(g)$$

propane   propene

Calculate the maximum mass, in kg, of hydrogen formed in this reaction.

(relative atomic mass: H = 1.0;
1 mol of any gas at room temperature and pressure occupies 24 dm^3)

(4)

$\frac{24}{900} = 0.02\dot{6}$ $\frac{900}{24} = 37.5$

ResultsPlus
Examiner Comments

This answer was given 0 marks.

The candidate has carried out 2 different calculations to give a part stage correct answer of 37.5 and an incorrect calculation. It's unsure from this which was the final answer as the answer line was blank, so no marks.

ResultsPlus
Examiner Tip

Examiners do not pick the best answer if more than one is given. All the candidate needed to do here was to put a line through the one they thought was incorrect, the examiner would then be able to mark the other one.

(c) 900 dm^3 of propane, measured at room temperature and pressure, were dehydrogenated to form propene.

$$C_3H_8(g) \rightleftharpoons C_3H_6(g) + H_2(g)$$

propane propene

Calculate the maximum mass, in kg, of hydrogen formed in this reaction.

(relative atomic mass: H = 1.0;
1 mol of any gas at room temperature and pressure occupies 24 dm^3)

(4)

$\frac{900}{24} = 37.5$ moles

1x6 = 6 mass = moles x Mr

37.5 x 2 = ~~225~~ 75

$\frac{75}{1000} = 0.075$

mass of hydrogen = 0.075 kg

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Examiner Comments

This answer was given all 4 marks.

Although the 2nd line contains an error [1 x 6 = 6 .... not sure where the '6' comes from], the candidate corrected this error in the 3rd line from 6 to 2 (relative formula mass of H_2) to give the mass of hydrogen in grams. Correct conversion to kilograms then followed.

Paper Summary

Based on the performance in this examination paper, candidates should

- practice in plotting and drawing graphs, especially with selecting an appropriate scale which makes the plotting of points easier
- recognise types of experiments that can be carried out in a school lab and those that are only workable in an industrial setting
- understand the purpose of each step in the sequence given in the method of the core practicals listed in the specification
- read information given in the stem of the question so that they do not repeat the information in their responses
- practice the different types of calculation found in the specification: candidates must be discouraged from giving two (or more) options for routes of calculations because ultimately, they could lose all the marks if no answer appears on the answer line
- avoid giving more points than asked for in their response as they may lose them marks if they include an incorrect point
- read their responses so that they do not contradict what they are trying to write
- be encouraged to spend some time improving their handwriting, at least to a level that makes it legible. Candidates can lose marks if examiners cannot read what they have written. The use of labelled diagrams may be helpful in some cases.

Grade boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

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