Examiners' Report
June 2014

GCSE Chemistry 5CH3H 01

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Introduction

This is the second examination of the Unit C3 paper in the GCSE Science 2011 specification.

The Higher Tier paper assesses grades A* to D and consists of a mixture of question styles, including objective questions, short answer questions, data analysis questions and extended writing style questions.

Students were assessed on their knowledge and understanding of qualitative analysis, quantitative analysis, electrolysis, equilibria and organic chemistry. There were opportunities for them to demonstrate their knowledge and understanding of writing balanced equations and practical work they have carried out throughout this Unit.

The overall impression of the examiners was that the majority of candidates had been very well prepared for the examination, with clear evidence of a sound understanding of many of the key concepts across the topic areas. Many excellent responses were seen, particularly to the more challenging questions, requiring extended writing.

Successful candidates:

- read the questions carefully and answered the questions as they were set;
- understood and used correct scientific terminology;
- could write balanced equations;
- could carry out calculations;
- could recall the procedures and results for testing for ions;
- could give well communicated descriptions and explanations for the electrolysis and for equilibrium reactions.

Less successful candidates:

- did not read the questions carefully and gave answers that were related to the topic being tested, but did not answer the question;
- could not write balanced equations;
- could not carry out calculations;
- had not revised how to test for the ions in the specification;
- confused the electrolysis of brine with that of that of molten sodium chloride.

In future, some candidates need to revise how to write ionic equations. Some candidates would also benefit from working through more questions involving calculations and electrolysis.

The report provides exemplification of candidates' work, together with tips and/or comments for a selection of questions. The exemplification is mainly confined to those questions requiring a more complex response from candidates.

Question 1 (b)

Most candidates gained full credit for showing the correct formulae for both reactants for the hydration of ethene.

Despite the reactants being given in the question, a large number of candidates were unable to recall the formula for ethene. Often the formula of ethane, C_2H_6, was shown, or C_2H_5 was given. Occasionally, candidates got the reactants and products the wrong way round. Several even got the formula for water wrong. Many candidates attempted to add a hydrocarbon and water to arrive at the product, a method that might have worked, but unfortunately were unable to work out the number hydrogen atoms in ethanol, with the hydrogen atom in the hydroxyl group omitted.

Question 1 (c) (i)

Many candidates were able to gain full credit.

The majority of candidates scored the 2 marks for references to 'same general formula' and 'similar chemical properties'. Often candidates could correctly recall the general formulae for various homologous series.

Often candidates failed to score due to being too vague, referring to 'same properties', 'similar structure', 'similar formula'. In a few cases, confused the definition for an homologous series with that of a hydrocarbon.

(i) Describe what is meant by an **homologous series**.

(2)

A homologous Series is a group of compounds that all have a Similar formula. This means they have a Similar molecular Structure, and have Similar properties.

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Examiner Comments

This was a commonly seen incorrect response seen by examiners. The three points made regarding 'similar chemical formula, structure and similar properties' are not specific enough, so this response did not score.

(i) Describe what is meant by an **homologous series**.

(2)

This means that they all share very similar properties and all follow the same general formula.

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Examiner Comments

This candidate mentions 'similar properties', but this is too vague, since there is no reference to 'similar chemical properties'. However, the reference to 'same general formula' is correct, so this scored 1 mark only.

(i) Describe what is meant by an **homologous series**.

(2)

A group of compounds all with the same general formula and the same functional group so that makes them all have similar chemical properties and react in same way.

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Examiner Comments

This is a very good example of a fully correct response. There are three creditworthy points made. The response scored the maximum 2 marks.

Question 1 (c) (ii)

This was very well answered on the whole. Most candidates could correctly draw the displayed formula for methanol.

Most incorrect responses showed an C-HO bond for an C-OH, or tried to make the oxygen double bonded, as in C=OH or C=O, as in an aldehyde.

Question 1 (d) (i)

Most candidates could correctly state that the type of reaction which occurs when ethanol changes into ethanoic acid is 'oxidation'. The most common incorrect responses often confused the oxidation process with 'fermentation' or 'reduction'.

Question 1 (d) (ii)

Most candidates typically scored at least 1 of the 2 marks available for 'fizzing and/or 'disappear'. Although, not desirable, 'dissolve' was credited as an alternative to 'disappear'.

The most commonly seen error was for candidates not giving observations, but either mentioning 'gas given off' or simply naming the species formed, hydrogen and/or magnesium ethanoate, or explaining the chemical process. The question specifically asks for what you would **see**, as opposed to an explanation.

(2)

You would see fizzing and bubbling of the magnesium and you would see the magnesium dissolve/eventually dissapear.

ResultsPlus
Examiner Comments

A good example of a fully correct response. Marking points 1 and 2 are for the correct references to 'fizzing/bubbling' and 'disappear'.

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Examiner Tip

Read the question carefully. This is a commonly asked question on the examination, so make sure you write down what is **seen**, rather than simply naming the chemical products or stating that a gas is given off. You cannot see a gas.

Question 2 (a) (i)

Many candidates scored full marks for recalling the correct test for iodide ions and the correct result.

Commonly seen errors, which limited the score to 1 mark, included:

- the incorrect reagent, often sodium hydroxide or hydrochloric acid, or an extra reagent was added, coupled with a correct result;
- a correct test stated with no result given;
- a correct test, but failing to mention either yellow or precipitate;
- a correct test, but giving the wrong colour precipitate, namely white or cream.

(i) Solid **A** is potassium iodide.

A small amount of solid **A** is dissolved in water to form a solution.

Describe the test to show that the solution of **A** contains iodide ions.

(2)

Silvernitrate and nitric acid is added to the solution of A. A yellow precipitate will form, showing that the solution contained iodide ions.

ResultsPlus
Examiner Comments

Although the word 'solution' is not mentioned and the reagents are not added in the desired order, this is sufficient to cover marking point 1', 'yellow precipitate' scores marking point 2. This scored full marks.

(i) Solid **A** is potassium iodide.

A small amount of solid **A** is dissolved in water to form a solution.

Describe the test to show that the solution of **A** contains iodide ions.

(2)

Add dilute nitric acid and the sliver ~~nitrate~~ nitrate ~~soln~~ solution.

ResultsPlus
Examiner Comments

The candidate mentions the correct reagents and in the correct order. Unfortunately, there is no mention of the correct observation. This response scored 1 mark.

Question 2 (a) (ii)

Many candidates knew how to test for ammonia, namely starting off with the addition of sodium hydroxide solution or by simply heating the solid. However, many did not score full marks, since either the solution was incorrectly tested, or the testing of a gas with red litmus (or action of holding the litmus paper over the mouth of the vessel) was often omitted. Most candidates were able to score the third marking point for the correct colour change of the litmus paper from red to blue. Surprisingly, several candidates got the colours the wrong way round, or confused this test with that for chlorine gas. Occasionally, candidates suggested a flame test for the potassium ions.

Describe the test to show that solid **B** contains ammonium ions.

(3)

The solid B would be heated with sodium hydroxide ~~to~~ in a test tube. The gas produced, ammonia, would have a distinctive smell and would turn damp red litmus paper blue if it was held in the mouth of the testtube.

ResultsPlus

Examiner Comments

A very good example where all the marking points are clearly covered, namely adding the correct reagent, testing of the gas with the correct indicator and the correct colour change.

Question 2 (b)

Most candidates knew the correct results for the addition of sodium hydroxide to aluminium or calcium ions and scored at least 2 marks out of the 3 marks available. Occasionally only 1 mark was scored, since the key words, 'precipitate' or 'white' were omitted.

However, the third marking point was less frequently scored, simply because the addition of 'excess' sodium hydroxide was not clearly stated. Many examiners noted that candidates often incorrectly discussed the use of flame tests to distinguish between the two metal ions.

(b) Sodium hydroxide solution can be used to test for aluminium ions and for calcium ions in solution.

Describe the results of these tests for aluminium ions and for calcium ions, explaining how the results distinguish between the two ions.

(3)

Both of these tests produce a white precipitate. However, aluminium can be distinguished as it's ~~easily~~ precipitate re-dissolves. Calcium stays in suspension.

(Total for Question 2 = 9 marks)

ResultsPlus

Examiner Comments

A good example of a 2 out of 3 marks response.

The key term 'excess' (or addition of more) sodium hydroxide has been omitted, so the third marking point was not scored.

Question 3 (b) (ii)

This was generally very well-answered. Most candidates scored the 2 marks available. They used the terms 'hydrophilic' and 'hydrophobic' and correctly described how these parts of the anion attach to water and the grease respectively. Unfortunately, it was noted that although candidates often used these correct terms for the parts of the ion, they often failed to mention the attachment to water or grease. Some candidates drew correctly labelled diagrams and scored both marks. References to the other marking points, namely to the 'lowering of surface tension' or 'soap surrounding the grease', were rarely seen.

Explain how soap anions remove grease marks from clothes during washing with water.

(2)

The soap anion contains a hydrophobic long hydrocarbon chain or 'tail', which dissolves in grease, and a hydrophilic ionic 'head', which dissolves in water. The soap anions surround the grease due to the tail and allow it to be lifted off by water due to the head.

ResultsPlus
Examiner Comments

Three of the possible four alternative marking points have been adequately covered, for the 'hydrophobic tail into grease', 'hydrophilic head in the water' and also 'soap anions surround the grease'. This response scored full marks.

There are hydrophillic and hydrophobic ends ~~parts~~ of the anion. The hydrophobic end doesn't like water and attaches itself to grease molecules. They detach from the clothes and remove themselves when the water is being washed away.

ResultsPlus
Examiner Comments

This was a typical response for 1 mark only. The correct scientific terms have been used, with the hydrophobic part correctly linked to the grease, but the hydrophilic end has not been linked to the water.

Question 3 (c) (i)

Most candidates were able to name the correct carboxylic acid, namely 'propanoic (acid)'. Occasionally, the names of different, incorrect carboxylic acids were given.

Question 3 (c) (ii)

Although there were some very good responses to this question, the majority achieved only 1 mark only for recognising water as a product. Most candidates struggled to write out the correct formula, either structural or molecular, for the ester. In many cases the attempted formula for the ester either contained an alcohol or carboxylic acid group.

Question 3 (d)

The majority of responses were able to score the 1 mark available for an acceptable use of polyesters, typically for 'making clothing'. A number of candidates gave 'plastic bags', which was not specific enough to gain credit. Several incorrectly suggested 'flavourings' or 'fragrances' as a use, namely a use for esters, but not for polyesters.

Question 4 (b)

This question was very poorly answered. Most candidates struggled with writing the ionic equation for neutralisation. It was apparent that very few candidates knew what is meant by an ionic equation, let alone how to write one.

Many wrote the full symbol equation, and in few cases, word equation. Some candidates were able to score 1 mark for the inclusion of the spectator ions, sodium and chloride ions, on both sides of the equation.

Question 4 (c)

Although there were many correct responses seen by examiners, typically for 'phenolphthalein' or 'methyl orange' coupled with their correct colour changes, many candidates incorrectly suggested indicator paper or 'universal indicator' as a suitable indicator. Centres need to stress to candidates that universal indicator solution is not acceptable for titrations.

Common errors were noted by examiners: extremely poor spelling, particularly for phenolphthalein, such that it was not phonetic and could not score. Occasionally, where a correct indicator had gained credit, the mark for the colour change was not scored, since the change was the incorrect way round or 'clear' was incorrectly used instead of 'colourless' when referring to phenolphthalein.

The hydrochloric acid is added from a burette to the sodium hydroxide solution in a conical flask.
At the end point the indicator changes colour.

(i) Give the name of a suitable indicator to use in this titration. **(1)**

phenolphthalein

(ii) State the colour change for this indicator at the end point. **(1)**

from pink to clear

ResultsPlus
Examiner Comments

This response mentions 'phenolphthalein' which scored 1 mark for part (i). Unfortunately, the second marking point (pink to colourless) for part (ii) was not awarded, since 'clear' is not equivalent to colourless.

ResultsPlus
Examiner Tip

This is a commonly asked question. It is worthwhile learning key indicators and their correct corresponding colour changes. Remember, universal indicator solution should never be used as an indicator for titration experiments.

The hydrochloric acid is added from a burette to the sodium hydroxide solution in a conical flask.
At the end point the indicator changes colour.

(i) Give the name of a suitable indicator to use in this titration. **(1)**

Phenolphthalein

(ii) State the colour change for this indicator at the end point. **(1)**

from colourless to Pink

ResultsPlus
Examiner Comments

This response scored 1 mark only for correct indicator (and spelled correctly) in part (i), but the colour change is the wrong way round, so the second marking point was not scored.

Question 4 (d)

The majority of candidates correctly calculated the correct concentration for the 2 marks available, or at least 1 mark for correctly calculating the Relative Formula Mass for sodium hydroxide. Commonly seen errors included: dividing the Relative Formula Mass (40 g) by the mass (20 g), namely 40/20, as opposed to the other way round, 20/40. Some calculated the mass concentration, 20 g dm^{-3}, which gained 1 mark only.

Question 4 (e)

Examiners were impressed by the high quality of responses seen, many scoring the full 3 marks available. It was evident that many candidates were able to use the formulae for calculating moles and concentrations competently. Occasionally, candidates inverted arithmetic or lost marks with powers of ten errors, so were limited to 1 or 2 marks. A few answers gained credit for clearly stating that the reactants were in a ratio 1:1.

(e) In another experiment, a titration was carried out.
25.0 cm^3 of 1.50 mol dm^{-3} sodium hydroxide solution, NaOH, was titrated with hydrochloric acid.
The volume of the hydrochloric acid required to neutralise the sodium hydroxide solution was 30.0 cm^3.

Calculate the concentration of the hydrochloric acid, HCl, in mol dm^{-3}.

$$HCl + NaOH \rightarrow NaCl + H_2O$$

(3)

Formula	Ratio	Concentration	volume	moles.
HCL	1	1.25	0.03	0.0375
NaOH	1	1.5	0.025	0.0375

Moles
Conc × vol

concentration = 1.25 mol dm^{-3}

ResultsPlus
Examiner Comments

A typical example of a fully correct response, 3 marks. This candidate has used the correct formula triangle and shown all the quantities in a table (correctly calculated the number of moles of sodium hydroxide, and recognised that the reaction is in a 1:1 ratio, and has then calculated the concentration of the hydrochloric acid).

Question 5 (a)

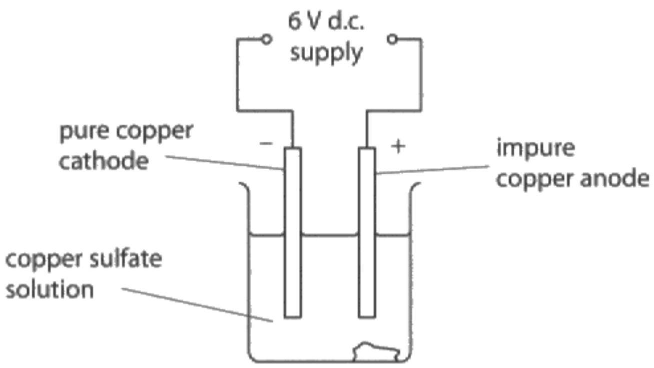
The majority of candidates were able to score the 1 mark available, with references to ‘improves resistance to corrosion’. The most common error was to mention ‘to prevent rusting’ which is clearly only specific to iron and steel. However, this was credited only if the rusting, when mentioned, was specifically linked to iron and steel. Some candidates confused ‘corrosive’ with ‘corrosion’. Several candidates incorrectly referred to ‘making the metal stronger’ or ‘making the metal conduct’ or simply repeated the reason already given in stem of the question.

Question 5 (b)

Although there were some excellent responses seen by examiners, gaining the full 3 marks available, the majority of candidates struggled with interpreting the results for the purification of copper by electrolysis in terms of atoms, ions and the redox processes occurring. Marks were generally awarded for stating 'the movement of copper ions from the anode to the cathode' or for a correct reference to 'the difference in the changes in mass (0.2 g) being down to impurities'.

Many answers referred to the change in mass of the anode or cathode, but did not explain this, or extend this sufficiently to explain the mass difference in terms of impurities. Few responses actually made specific reference to the oxidation/atoms losing electrons or reduction/ions gaining electrons at the anode and cathode respectively. Half equations were rarely given.

(b) Copper sulfate solution was electrolysed using copper electrodes.
The mass of each electrode was determined before it was placed in the solution.



The electrolysis was carried out for a period of time.
The electrodes were removed, washed, dried and their masses redetermined.

The table shows the masses of the electrodes before and after electrolysis.

	mass of electrode before electrolysis / g	mass of electrode after electrolysis / g	change in mass
mass of impure copper anode	40.0	35.0	5.0 g decrease
mass of pure copper cathode	10.0	14.8	4.8 g increase

Explain these results.

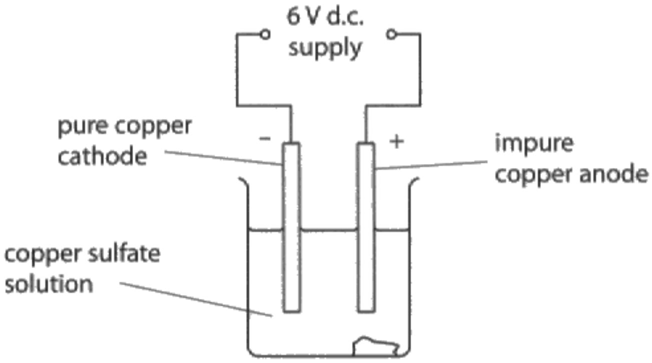
(3)

Because the copper was attracted to the cathode which increased the amount of copper in the cathode while there was a reduction in the anode as the copper migrated to the cathode leaving just the impurities.

ResultsPlus
Examiner Comments

In this response there is no mention of copper ions or the movement of copper ions, or copper atoms being formed. The impurities are not linked to the 0.2g difference in the mass changes. This response scored 0 marks.

(b) Copper sulfate solution was electrolysed using copper electrodes.
The mass of each electrode was determined before it was placed in the solution.



The electrolysis was carried out for a period of time.
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The table shows the masses of the electrodes before and after electrolysis.

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mass of impure copper anode	40.0	35.0	5.0 g decrease
mass of pure copper cathode	10.0	14.8	4.8 g increase

Explain these results.

(3)

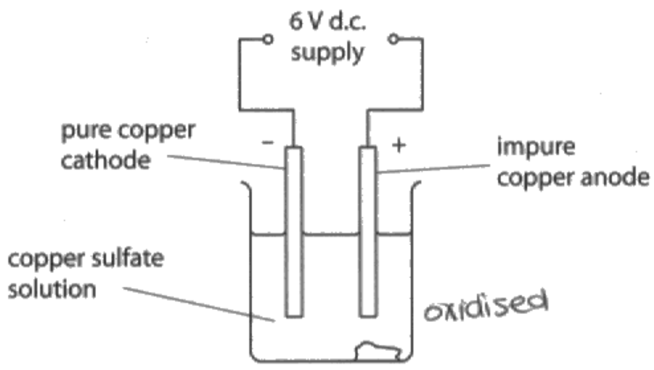
At the anode, copper atoms are oxidised, meaning they lose electrons, forming Cu^{2+} ions that enter into solution. At the cathode, electrons are offered up to nearby Cu^{2+} ions forming copper ~~atom~~ ~~molecul~~ atoms which stick to the cathode. This means that the anode loses 5 g of mass because copper is stripped off, and the cathode gains 4.8 g because copper is added to it.

ResultsPlus

Examiner Comments

The processes occurring at the anode and cathode have been discussed in detail. There has been no further discussion of the 0.2g change in mass difference linked to impurities or any mention of movement of ions. This response scored 2 marks.

(b) Copper sulfate solution was electrolysed using copper electrodes.
The mass of each electrode was determined before it was placed in the solution.



The electrolysis was carried out for a period of time.
The electrodes were removed, washed, dried and their masses redetermined.

The table shows the masses of the electrodes before and after electrolysis.

	mass of electrode before electrolysis / g	mass of electrode after electrolysis / g	change in mass
mass of impure copper anode	40.0	35.0	5.0 g decrease
mass of pure copper cathode	10.0	14.8	4.8 g increase

Explain these results.

(3)

There was a 4.8g increase on the copper cathode because the copper ~~mett~~ metal was oxidised at the anode and formed Cu^{2+} ions in solution and then were ~~ox~~ reduced at the cathode to form Solid copper atoms coating the cathode ~~this~~ This is why The anode decreased in mass by 5g and 0.2g of this ~~was~~ was all impurities ~~dep~~ causing a 4.8g increase in cathode mass

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Examiner Comments

A typically seen very good response. Three marking points have been mentioned in this response. The formation of copper ions at the anode/oxidation. The reduction of copper ions at the cathode to form copper atoms. The difference in the change in mass has been correctly linked to impurities. This response scored 3 marks.

Question 5 (c)

This question was very poorly answered by the majority of candidates, with very few candidates scoring the 2 marks available. In cases where 1 mark was scored, it was invariably for showing the correct species on both sides of the equation, but with incorrect balancing, typically for showing only 2 electrons, rather than 4 electrons on the Right Hand Side of the equation. The majority of answers which failed to score, reference to gaining electrons on the Left Hand Side. In some responses this reaction was confused with the oxidation half equation occurring at the anode during the electrolysis of water.

(c) In an electrolysis experiment, oxide ions, O^{2-}, form oxygen gas, O_2.

Write the balanced half equation for the reaction.

(2)

$O^{2-} \rightarrow O_2 + 2e$

ResultsPlus
Examiner Comments

A typical 1 mark response for showing the correct species but incorrect balancing, namely the **2** on the LHS is missing and **2**e^- is incorrect on the RHS.

Question 5 (d)

A significant number of excellent answers were noted by the examiners, gaining the maximum 6 marks, Level 3. There was good recognition of the movement of sodium ions and chloride ions to the correct electrodes and the subsequent reduction and oxidation reactions. The use of half equations for the reduction and oxidation processes was seen occasionally. Very few candidates discussed the fact that two chlorine atoms joined to form a chlorine molecule.

Level 2 responses often showed less detail regarding electron transfer following movement of ions to the electrodes. Often candidates incorrectly referred to chlorine ions instead of chloride ions. Some candidates confused the electrolysis of an aqueous solution of sodium chloride / brine with that of molten sodium chloride in the question, despite some detailed explanations, which often limited the answers to Level 2. In some cases, it was disappointing to see atoms with charges or ions going to the wrong electrodes, or confusing the anode with the cathode.

*(d) Sodium chloride is an ionic compound.
It contains sodium ions, Na^+, and chloride ions, Cl^-.

neg   pos

When molten sodium chloride is electrolysed, sodium metal and chlorine gas are formed.

Describe how the sodium ions and chloride ions in solid sodium chloride are converted into sodium and chlorine by electrolysis.

(6)

In electrolysis, the sodium ions are attracted towards the cathode as they contain positive ions. which converts it into a sodium metal. The chloride ions are attracted towards the anode as they contain negative ions which forms a chlorine gas.

Sodium goes to the cathode because its ~~an~~ a negative electrode and the sodium ~~is~~ ions are ~~negative~~ positive. Chloride ions go to the anode ~~as~~ because its a positive electrode and the chloride ions are negative.

This forms sodium and chlorine as they are both attracted to the different electrodes.

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Examiner Comments

This response correctly mentions the movement of sodium ions and chloride ions to the cathode and anode respectively. The formation of chlorine gas at the anode and sodium metal at the cathode have been discussed. There have been four relevant points made. This response scored 4 marks - Level 2.

*(d) Sodium chloride is an ionic compound.
It contains sodium ions, Na^+, and chloride ions, Cl^-.

When molten sodium chloride is electrolysed, sodium metal and chlorine gas are formed.

Describe how the sodium ions and chloride ions in solid sodium chloride are converted into sodium and chlorine by electrolysis.

(6)

The sodium ions from the solution are pulled towards the cathode of the electrolysis because opposite charges attract. The chloride ions are pulled towards the anode.

ResultsPlus
Examiner Comments

Two correct points have been made, namely the movement of sodium ions to the cathode and chloride ions to the anode. This response scored 2 marks - Level 1.

When the sodium chloride is electrolysed the sodium ions are attracted to the negatively charged cathode as they are positive. ~~The pos negative~~ They are then reduced as they gain electrons. The negative ~~anions~~ ~~are attracted~~ chloride ions are attracted to the positively charged anode. they are oxidised as they lose electrons.

ResultsPlus
Examiner Comments

The movement of the sodium ions to the cathode and chloride ions to the anode are mentioned. Redox reactions at the electrodes have been discussed, namely chloride ions losing electrons / oxidation and sodium ions gaining electrons / reduction. Overall, although the answer is relatively concise, there are six relevant points regarding both the electrode processes, so this response is sufficient for Level 3 and scored 6 marks.

Two inert electrodes are used, supplied with a current and put into an electrolyte of molten sodium chloride, where Na^+ and Cl^- ions are free to move. At the negative cathode Na^+ cations are reduced, and gain electrons, to be deposited as solid sodium atoms. The half equation is: $Na^+_{(l)} + e^- \rightarrow Na_{(s)}$. The sodium is collected and used in street lamps and as a coolant in some nuclear reactors.

Chloride anions are instead attracted to the anode where they are oxidised, and lose electrons to form chlorine gas molecules. The half equation is: $2Cl^-_{(l)} \rightarrow Cl_{2(g)} + 2e^-$. Chlorine is collected at the anode as a toxic green gas and is used to treat water, produce bleach and to make PVC and other polymers.

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Examiner Comments

This is an excellent example of typical Level 3 response - 6 marks.

The movement of ions to the respective electrodes has been discussed and the electrode processes at the anode and cathode have been described and explained in detail, coupled with detailed half-equations. There are greater than the minimum valid points required for Level 3.

Question 6 (b)

Many responses scored the full 2 marks available. The majority gained at least 1 mark for correctly calculating the number of moles of zinc used or hydrogen formed, namely 0.2 moles. Many were able to recognise that to calculate the volume of hydrogen, then the number of moles needed to be multiplied by 24, to achieve 4.8 dm³. Occasionally, after having obtained the correct answer, candidates then incorrectly multiplied this answer by 2, to give a final answer of 9.6, so only scoring 1 mark.

(b) Zinc reacts with dilute hydrochloric acid to form zinc chloride and hydrogen.

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

13g ?

Calculate the maximum volume of hydrogen formed, at room temperature and pressure, when 13.0 g of zinc reacts completely with excess hydrochloric acid.
(relative atomic mass: Zn = 65.0,
1 mol of any gas occupies 24 dm³ at room temperature and pressure)

(2)

A_r Zn = 65 1mole Zn → 1mole H_2
65g = 1mole 0.2mol Zn → 0.2mol H_2
13g = 0.2mol
1mol = 24dm3
0.2mol = 4.8dm3

volume of hydrogen = 4.8 dm³

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Examiner Comments

A typical response. This candidate has clearly laid out the working in logical steps to arrive at the correct answer, 4.8 dm³. This response scored 2 marks.

Question 6 (c) (ii)

This question was extremely well answered, with most candidates scoring the full 2 marks for 'dynamic equilibrium'. When a 1 mark response was seen occasionally, it was for simply mentioning just 'equilibrium' only or simply mentioning 'reversible reaction'.

Question 6 (d)

The quality of many of the responses seen by examiners was exemplary. At Level 3, for 6 marks, many candidates were able to explain in detail the conditions used in the Haber process for the manufacture of ammonia, namely the effects of temperature and pressure and the use of a catalyst on yield and rate in equilibrium reactions. The explanations for the effect of increasing pressure were particularly well developed by candidates, but less so for the effects of temperature or the use of a catalyst.

At Level 2, for 4 marks, tended to discuss the effects of changing the conditions on yield and rate of reaction on the Haber process, with no detailed explanation.

Commonly seen areas of weakness or misconceptions included:

- a confusion over the effect of increasing the temperature, many candidates incorrectly thought that this would increase the yield of ammonia;
- a limited knowledge of how a catalyst affects an equilibrium reaction, such that this was often limited to a catalyst speeding up the rate of a reaction;
- explanations for the increasing rate of reaction using collision theory were often not well-developed.

It is also worthwhile noting that the 'optimum' conditions, for the pressure and temperature used, for the Haber process will vary depending on the sources used, such that those in the question may have not necessarily been the same as those shared with candidates when teaching this topic at centres.

*(d) The reaction between nitrogen and hydrogen is exothermic.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

If nitrogen and hydrogen were reacted at 90 atm pressure and 300 °C, without a catalyst, some ammonia would be formed eventually.

In the Haber process a pressure of 150 atm and a temperature of 450 °C are used, in the presence of an iron catalyst.

Explain, with reasons, why the Haber process conditions are better for the manufacture of ammonia.

(6)

A catalyst speeds reactions up, without being used. The iron catalyst does this to make ammonia quicker. The increased pressure forces the yield upwards because there are less [illegible] forces on the right hand side of the equation. Heat increases speed in a reaction. This reaction requires colder temperatures to increase the yield. A [illegible] compromise is made to keep the speed of the reaction up.

ResultsPlus

Examiner Comments

An example of a Level 2, 4 marks, response.

Three effects of change have been discussed: a catalyst speeds up the rate of reaction; increasing pressure - increases the yield, but this is not explained correctly; heat increases (equivalent to increased temp, although poorly expressed) - increases speed of reaction and the effect of using of a lower temperature - increases yield (but there is a compromise between speed and yield).

*(d) The reaction between nitrogen and hydrogen is exothermic.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

If nitrogen and hydrogen were reacted at 90 atm pressure and 300 °C, without a catalyst, some ammonia would be formed eventually.

In the Haber process a pressure of 150 atm and a temperature of 450 °C are used, in the presence of an iron catalyst.

Explain, with reasons, why the Haber process conditions are better for the manufacture of ammonia.

(6)

A high temperature means the reaction will be fast but low yeild. A lower temperature means more yeild but more time.

ResultsPlus

Examiner Comments

An example of a Level 1, 2 marks, response.

Two effects due to temperature have been discussed: increasing temperature - increases speed and lowers yield (of ammonia). The reverse argument is also given.

*(d) The reaction between nitrogen and hydrogen is exothermic.

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(6)

The higher pressure of 150atm in the Haber process is better for the manufacture of ammonia as it increases the rate of reaction, as the reactants collide more frequently, and it increases the yield of ammonia as the higher pressure favours the reaction that produces a lower volume of gas, with fewer moles of gas, so the ammonia in this case. The higher temperature decreases the yield of ammonia, as it favours the endothermic reaction to produce hydrogen and nitrogen, using up the excess energy, but it increases the rate of reaction as the reactants collide more frequently. Therefore, much more ammonia can be produced quickly, so it is better for the ~~[illegible]~~ industrial manufacture of ammonia. An iron catalyst is better than no catalyst as it lowers the activation energy required for the reactions, so it increases the rate of reaction and allows the reactions to reach equilibrium sooner, so ammonia can be made faster, so this is better than no catalyst.

This means that the Haber process conditions manufacture ammonia at a faster rate, so ~~[illegible]~~ the manufacturers ~~[illegible]~~ can get more money quickly.

(Total for Question 6 = 12 marks)

TOTAL FOR PAPER = 60 MARKS

ResultsPlus

Examiner Comments

A typical example of a very detailed answer, Level 3, 6 marks.

The candidate has described all the valid effects of changing all three conditions, with at least two points of explanation for each change: higher pressure - increases speed and increases yield, with an explanation in terms of decreased number of moles/volume and collision theory; higher temperature - decreases yield and increases speed, with an explanation in terms of favouring the endothermic (back) reaction and collision theory; use of a catalyst - speeds up rate, equilibrium reached faster and lowers activation energy.

Paper Summary

In order to improve their performance, candidates should:

- read all the information in the question carefully and use this to help them to answer the question.
- practise writing balanced equations from the specification which regularly appear in the examination, including esterification and the correct formulae for esters, the hydration of ethene and ionic equations, especially for neutralisation reactions.
- revise the correct procedure and results for testing the ions in the specification.
- learn the names of commonly used indicators for titrations and their correct colour changes, and to avoid the use of universal indicator for titrations.
- be able to describe the processes occurring in electrolysis reactions in the specification and to explain these in terms of the redox processes occurring, especially for the purification of copper, the electrolysis of molten salts and solutions of salts, and to avoid incorrectly using chlorine ion instead of the correct term, chloride ion.

Grade Boundaries

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