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Examiners' report

CHEMISTRY A

H[redacted]32
For first teaching in 2015

H032/02 Summer 2019 series

Version 1

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates. The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report. A full copy of the question paper can be downloaded from OCR.

Paper 2 series overview

H032/02 is one of the two examination components for GCE Chemistry A. This synoptic depth in chemistry paper links together content from all four modules. To do well on this paper, candidates needed to apply their knowledge and understanding to unfamiliar contexts and be familiar with a range of practical techniques. This paper discriminated well and, in general, the standard of mathematical calculations was answered better than descriptive questions. There was no evidence that the candidates had run out of time.

Candidates who did well on this paper generally did the following:

- Performed standard calculations and graph plotting with clear working, significant figures and Units: 1(a) (ii) use of isotopic data; 1 (d) (i) calculating the water of crystallisation to 2 significant figures; 2 (a) calculating the correct mass of magnesium nitrate; 2 (b) calculating the minimum volume of nitric acid required to 3 significant figures; 4 (a) calculating the volume of hydrogen produced; 4 (b) (i) linear numerical scale chosen with units, points plotted accurately; 5 (b) (i) calculating the correct mass of hexan-1-ol
- Produced clear and concise responses for level of response Questions 2 (a) and 5 (b) (i)
- Drew clear diagrams and explained the physical properties of a metal: 1 (b)
- Accurately drew the mechanism for an organic reaction: 3 (a) (i)
- Accurately drew a graph, identified the anomaly, drew a line of best fit and sketched a curve for an experiment with no data

Candidates who did less well on this paper generally did the following:

- Lost valuable marks on Question 2 (a) as they did not answer the question and instead of describing how to make up a standard solution, described the method to remove water of crystallisation
- For 4 (b) (i) did not use a linear numerical scale for the x axis or did not include units
- Either did not draw, or incorrectly sketched a curve for 4 (c)
- Produced responses that lacked depth, in particular Question 5 (b) (i) had relevant information about the densities and boiling points of the components of the mixture, but this was often ignored

Note

From this series students have been provided with a fixed number of answer lines and an additional answer space. The additional answer space will be clearly labelled as additional, and is only to be used when required. Teachers are encouraged to keep reminding students about the importance of conciseness in their answers. Please follow this link to our SIU (https://www.ocr.org.uk/administration/support-and-tools/siu/alevel-science-538595/

Question 1 (a) (i)

1 This question is about the properties and reactions of the Group 2 element strontium.

(a) The relative atomic mass of strontium can be determined using a mass spectrometer.

(i) Explain what is meant by the term **relative atomic mass** of an element.

....

....

....

.... **[2]**

Most candidates were given at least one mark but lost the second mark due to omitting the word "atom", or "mean" or "one-twelfth"

Question 1 (a) (ii)

(ii) A sample of strontium has a relative atomic mass of 87.73.

The sample consists of:

- 82.9% Sr-88
- 6.9% Sr-87
- one other isotope.

Determine the other isotope of strontium in the sample.

isotope of strontium = ... **[2]**

Algebra was used very well here and allowed most candidates to obtain at least one mark, with the majority obtaining 2 marks

Question 1 (b)

(b) The table below shows two physical properties of the element strontium.

Melting point	high
Electrical conductivity	very good

Explain these physical properties of strontium, in terms of bonding and structure.
Include a labelled diagram in your answer.

Diagram

Explanation ....

....

....

....

....

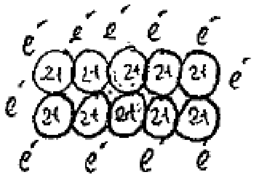
....

.... **[5]**

In general, the diagrams were poorly drawn or inadequately labelled. Many candidates lost marks as they did not specify the **movement** of electrons as the reason why metals conduct electricity. Too many candidates wrote "delocalised electrons carry the charge" or negated the metallic bonding description with "intermolecular forces" in their responses.

Exemplar 1

Diagram

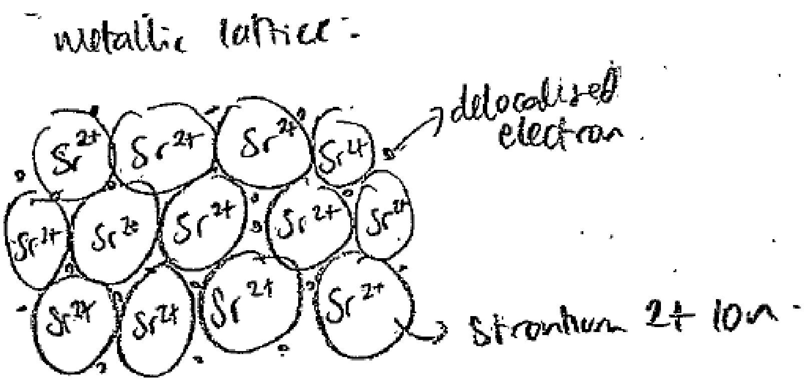


Explanation Metallic bonding: strong forces of attraction between lattice of positive ions and sea of delocalised electrons. As there are free moving electrons, which can carry a current, the element strontium has a very good electrical conductivity. Strontium has a giant structure, which is why it has a high ~~pett~~ melting point as ~~the~~ it requires high amounts of energy to overcome the strong forces of attraction: as metallic bonds are strong.

This candidate scored 3 marks for the description but lost 2 marks as the electrons were not throughout the structure, merely drawn around the ions, and the positive ions were not labelled.

Exemplar 2

Diagram



Explanation: Strontium is a group 2 metal. This means it forms metallic bonds in which Strontium ions (2+ charge) are attracted to the negatively charged delocalised electrons. These delocalised electrons are able to move around the lattice and so therefore are able to carry a current of electricity even as a solid. This makes it a good electrical conductor. It has a high melting point due to the strong electrostatic forces of attraction that need to be overcome in order for it to change state. **[5]**

This candidate scored 5 marks for the excellent description with a well drawn and labelled diagram, clearly showing the electrons throughout the structure in-between the ions.

Question 1 (c) (i)

(c) A student adds a small amount of strontium to water.

When the reaction has finished, the student measures the pH of the final solution.

(i) Write the equation for the reaction of strontium with water.

.... **[1]**

Nearly half of the candidates did not answer this question correctly, mainly because of incorrect balancing or the formation of strontium oxide instead of strontium hydroxide.

Question 1 (c) (ii)

(ii) Describe **two** observations which would be different if the student had used calcium in place of strontium.

1 ....

....

2 ....

.... **[2]**

Most candidates were able to identify at least one difference, although a significant number of responses stated the opposite trend

Question 1 (d) (i)

(d) When hydrated strontium chloride is heated, the water of crystallisation is removed, leaving a residue of anhydrous strontium chloride.

A student carries out an experiment to find the value of **x** in the formula of hydrated strontium chloride, $SrCl_2 \bullet \mathbf{x}H_2O$.

The student's method is outlined below.

Step 1
Weigh an empty crucible.
Add $SrCl_2 \bullet \mathbf{x}H_2O$ to the crucible and reweigh.

Step 2
Heat the crucible and contents for 10 minutes.
Allow to cool and reweigh.

Step 3
Heat the crucible and residue for another 5 minutes.
Allow to cool and weigh the crucible and residue.

Repeat step 3 a further two times.

The student's results are shown below:

Mass of empty crucible / g	15.96
Mass of crucible + $SrCl_2 \bullet \mathbf{x}H_2O$ / g	18.65
First mass of crucible + residue / g	17.66
Second mass of crucible + residue / g	17.61
Third mass of crucible + residue / g	17.58
Fourth mass of crucible + residue / g	17.58

(i) Calculate the value of **x** in $SrCl_2 \bullet \mathbf{x}H_2O$.

Give your answer to **2** significant figures.

x = ... **[3]**

Most students managed to gain some marks on this question. The most common error was rounding to 6, something they have been taught to do for water of crystallisation. This caused them to lose a mark as the question asked for two significant figures. Many rounded too early so a variety of responses were seen.

Question 1 (d) (ii)

(ii) Suggest why the student takes four readings of the mass of the crucible and residue.

....

.... **[1]**

The majority of candidates answered this correctly, the main incorrect answer was "to achieve constant mass".

Question 1 (d) (iii)

(iii) Suggest **two** modifications to the method that would reduce the percentage uncertainty in the mass of the residue.

1 ....

....

2 ....

.... **[2]**

Most candidates identified either using a larger mass or a more accurate balance, not many stated both. The most common incorrect answers involved heating for longer or taking less measurements.

Question 2 (a)

2 Magnesium nitrate is used in fertilisers as a source of nitrogen.

(a)* A student plans to prepare 250.0 cm^3 of a 0.4000 mol dm^{-3} solution of magnesium nitrate, starting from magnesium nitrate crystals, $Mg(NO_3)_2$•$6H_2O$.

Describe how the student would prepare the solution, giving full details of quantities, apparatus and method. **[6]**

Most candidates focused on removing the water of crystallisation, often going to great depths of explanation, with apparatus diagrams, of how to remove it. Some candidates then went on to explain how to make a standard solution and could be given marks. Calculations for the mass required were often correct or could be given some marks.

Exemplar 3

$C = \frac{Mol}{vol}$ $\frac{250}{1000} \times 0.4 = 0.1$ moles of $Mg(NO_3)_2$ needed

0.1 moles of

- add ~~the~~ crystals to a crucible and wiegh ~~each~~ both seperately using wieghing scales set to zero.

- then heat the crystals to a constant mass using a bunsen burner & ensure this mass of $Mg(NO_3)_2$ is 14.83g

- add these crystals to a volumetric flask with $100cm^3$ of water, then stir it & make sure the crystals dissolve in the solvent (water)

- then fill the rest of the volumetric flask up to $250cm^3$, ensuring the bottom of the meniscus is where you are measuring to.

Additional answer space if required

$0.1 \times (24.3 + 2(14 + (16)3)_2)$

$= 14.83g$

$\Rightarrow$ mass of $Mg(NO_3)_2$ that should be left after heating to constant mass.

This in a response of a common approach to this question, it was given 4 marks. Despite calculating the mass properly, the candidate then put all their efforts into describing removing the water of crystallisation and left out the valuable fine detail required for a Level 3 response.

Question 2 (b)

(b) A solution of magnesium nitrate can be prepared by reacting magnesium carbonate, $MgCO_3$, with nitric acid, $HNO_3(aq)$.

The equation is shown below.

$MgCO_3(s) + 2HNO_3(aq) \longrightarrow Mg(NO_3)_2(aq) + H_2O(l) + CO_2(g)$

Calculate the minimum volume, in cm^3, of 1.75 mol dm^{-3} HNO_3 that is needed to prepare a solution containing 5.00 g of $Mg(NO_3)_2$.

Give your answer to **3** significant figures.

volume = ... cm^3 **[3]**

This question was answered well, with the majority of the candidates obtaining 3 marks.

Question 2 (c)

(c) Magnesium nitrate decomposes when heated, as shown in the equation.

$2Mg(NO_3)_2(s) \longrightarrow 2MgO(s) + 4NO_2(g) + O_2(g)$

Using oxidation numbers, show which element has been oxidised and which has been reduced when magnesium nitrate decomposes.

State the changes in oxidation numbers, including all signs.

Element oxidised ....

Oxidation number change: from .... to ....

Element reduced ....

Oxidation number change: from .... to ....

[2]

Less than half the candidates answered this question correctly. This may be because they are not used to assigning oxidation numbers within formulae that contain brackets.

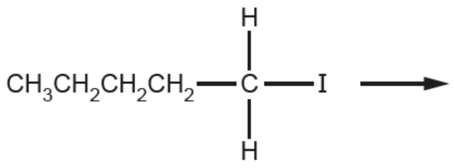
Question 3 (a) (i)

3 This question is about 1-iodopentane, $CH_3CH_2CH_2CH_2CH_2I$.

(a) 1-Iodopentane can be hydrolysed by aqueous sodium hydroxide.

(i) Outline the mechanism for this reaction.

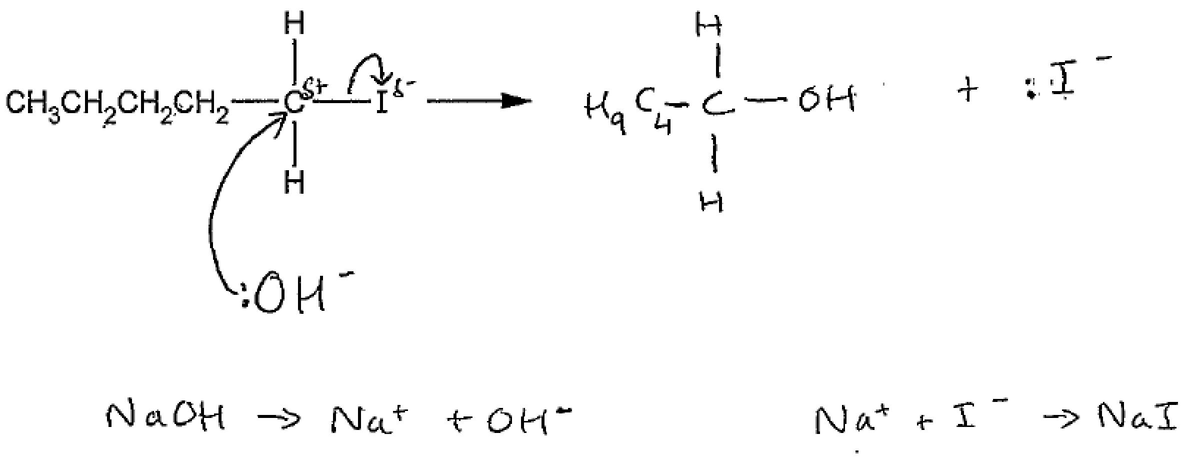
Include curly arrows, relevant dipoles and the final product(s).



[3]

Those that had learnt this important mechanism scored all 3 marks with very precisely drawn arrows and partial charges. Although many candidates wrote out the correct organic product, many wrote NaI instead of I^- which lost them the final mark.

Exemplar 4



This candidate scored all 3 marks. The lone pair of electrons on the oxygen and partial charges on the C-I bond are clearly marked on the diagram and the arrows are precisely drawn. Connectivity is good on the organic product and I^- identified as the additional product.

Question 3 (a) (ii)

(ii) 1-Iodopentane can also be hydrolysed by water using aqueous silver nitrate, with ethanol as the solvent.

A student uses this method to compare the rates of hydrolysis of 1-iodopentane and 1-bromopentane.

What measurement and observation would allow the student to compare the rates of hydrolysis?

....

.... **[1]**

The question asked for the measurement AND observation, many students did not answer both parts and therefore did not gain any marks. "How fast" and "how long" were not given as they did not detail the measurement.

Question 3 (a) (iii)

(iii) 1-Iodopentane was found to react faster than 1-bromopentane.

Explain why.

....

....

.... **[2]**

Answers were too vague to be given in most cases. Candidates referred to bonds being broken or overcome, but did not specify C-I bonds breaking, or discussed iodine and bromine in terms of reactivities.

Question 3 (b) (i)

(b) The mass spectrum of 1-iodopentane is shown below.

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(i) What information is given by the peak labelled **X** (*m*/*z* = 198)?

.... **[1]**

This was generally well answered. The most common incorrect answer was atomic mass.

Question 3 (b) (ii)

(ii) Write the structural formulae of the ions responsible for the peaks labelled **Y** and **Z**.

Y (*m*/*z* = 71) ....

Z (*m*/*z* = 43) .... **[2]**

Most students gained one mark on this question as they omitted the + sign or wrote the molecular formula instead of the structural formula.

Question 3 (c) (i)

(c) 2-Iodo-2-methylbutane is an isomer of 1-iodopentane.

(i) Draw the structure of 2-iodo-2-methylbutane.

[1]

This was well answered by most candidates

Question 3 (c) (ii)

(ii) Suggest **one** similarity and **one** difference between the mass spectra of 1-iodopentane and 2-iodo-2-methylbutane.

Similarity ....

....

Difference ....

.... **[2]**

Most candidates answered the similarity part correctly, many wrote vague answers to the difference and were not specific. A common error focused on the peak at m/z = 71, very few recognised that the Z peak at 43 would not be present for 2-iodo-2-methylbutane

Question 4 (a)

4 Zinc reacts with hydrochloric acid, $HCl(aq)$, as shown in the following equation.

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

A student investigates the rate of this reaction.

(a) The student plans to react $50.0\,cm^3$ of $0.100\,mol\,dm^{-3}$ HCl with 0.200 g of zinc (an excess).

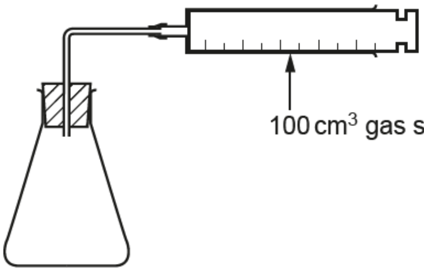
Calculate the volume, in cm^3, of hydrogen that should be produced at RTP.

volume = ... cm^3 **[3]**

This was a well answered question, with the majority of candidates obtaining all 3 marks

Question 4 (b)

(b) The student uses the apparatus in the diagram.



The student's method is outlined below:

- Pour 50.0 cm^3 of 0.100 mol dm^{-3} HC*l* into the conical flask.
- Add 0.200 g of zinc (an excess), and quickly attach the delivery tube and gas syringe.
- Measure the volume of gas collected every 20 seconds until the reaction stops.

The student obtains the results shown in **Table 4.1**.

Time / s	0	20	40	60	80	100	120	160	200
Volume of gas / cm^3	0	16	27	37	39	50	53	58	58

Table 4.1

(i) On the graph paper in **Fig. 4.1**, label the x axis **and** plot the results in **Table 4.1**. **[1]**

Most candidates obtained this mark, some lost the mark because they did not use a linear scale or provide units.

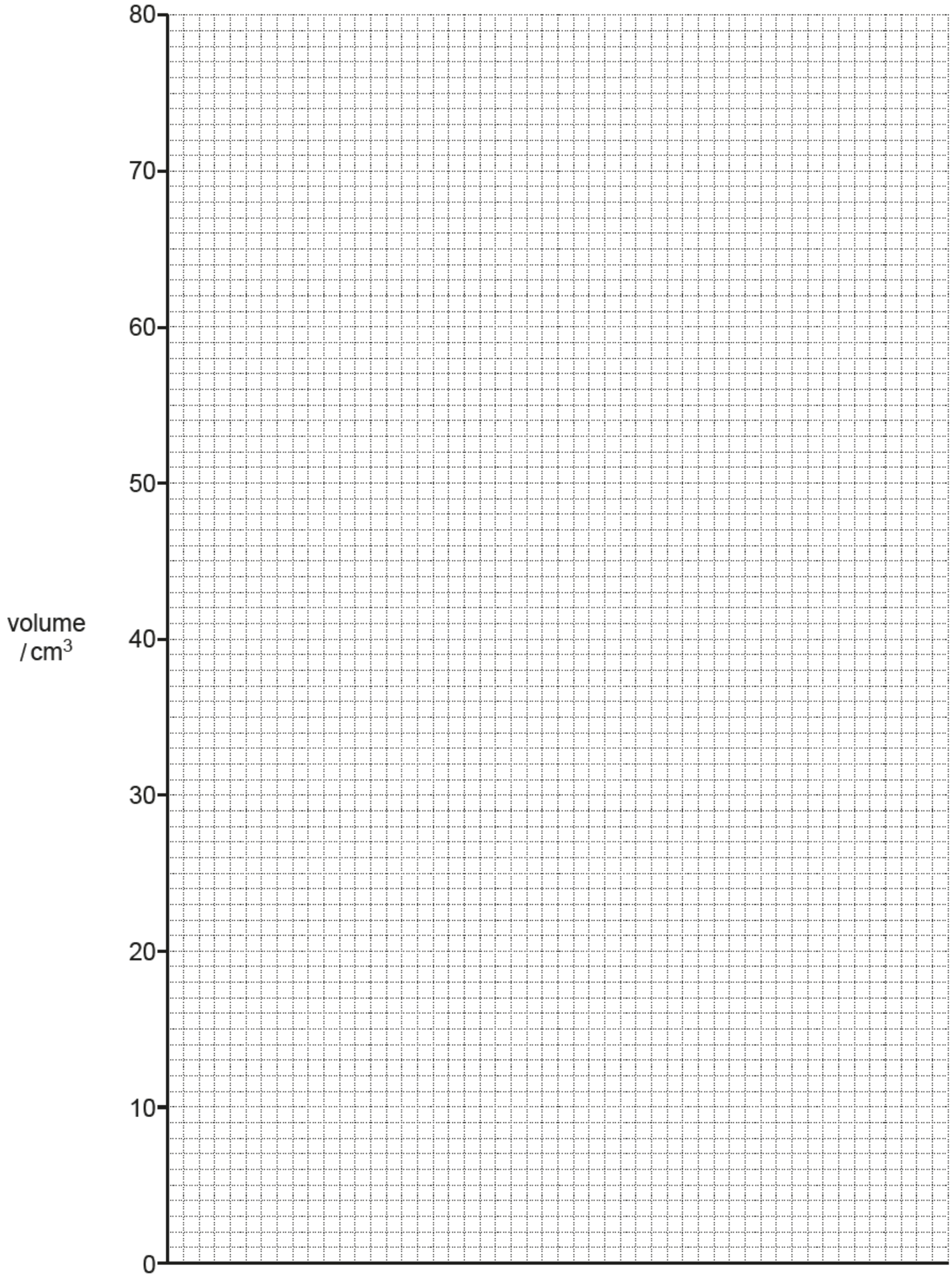


Fig. 4.1

Question 4 (b) (ii)

(ii) Circle any anomalous results present in the graph you have drawn in **Fig. 4.1**. **[1]**

Nearly all the candidates obtained this mark

Question 4 (b) (iii)

(iii) Draw a best-fit smooth curve on the graph you have drawn in **Fig. 4.1**. **[1]**

Nearly all the candidates obtained this mark

Question 4 (c)

(c) The student repeats the experiment using:

- zinc with the same mass (0.200 g) and same surface area
- the same temperature and pressure
- 40.0 cm^3 of 0.125 mol dm^{-3} HCl, instead of 50.0 cm^3 of 0.100 mol dm^{-3} HCl.

On your graph in **Fig. 4.1** sketch the curve you would expect in this experiment. **[2]**

Many students did not sketch this curve or sketched a curved that was less steep and did not finish at 58 cm^3.

Question 4 (d)

(d) The graph shows that rate of reaction decreases over time.

Explain why, in terms of collision theory.

....

....

....

....

.... **[2]**

Many responses detailed why the graph was steep at the beginning, rather than answering the question. Those that did explain the decrease often omitted the words concentration and frequency so the majority did not gain 2 marks. A large number of candidates discussed particles "losing energy" and "less successful collisions" so were not given any marks.

Question 4 (e) (i)

(e) (i) The rate of the reaction between zinc and hydrochloric acid can be increased using a solution of copper(II) sulfate as a catalyst.

Explain how a catalyst increases the rate of reaction.

....

....

....

....

.... **[2]**

Most candidates scored the first marking point but many did not achieve the second marking point as their explanations were too vague.

Question 4 (e) (ii)

(ii) Why is it difficult to classify the solution of copper(II) sulfate as a homogeneous or heterogeneous catalyst in this reaction?

....

....

.... **[1]**

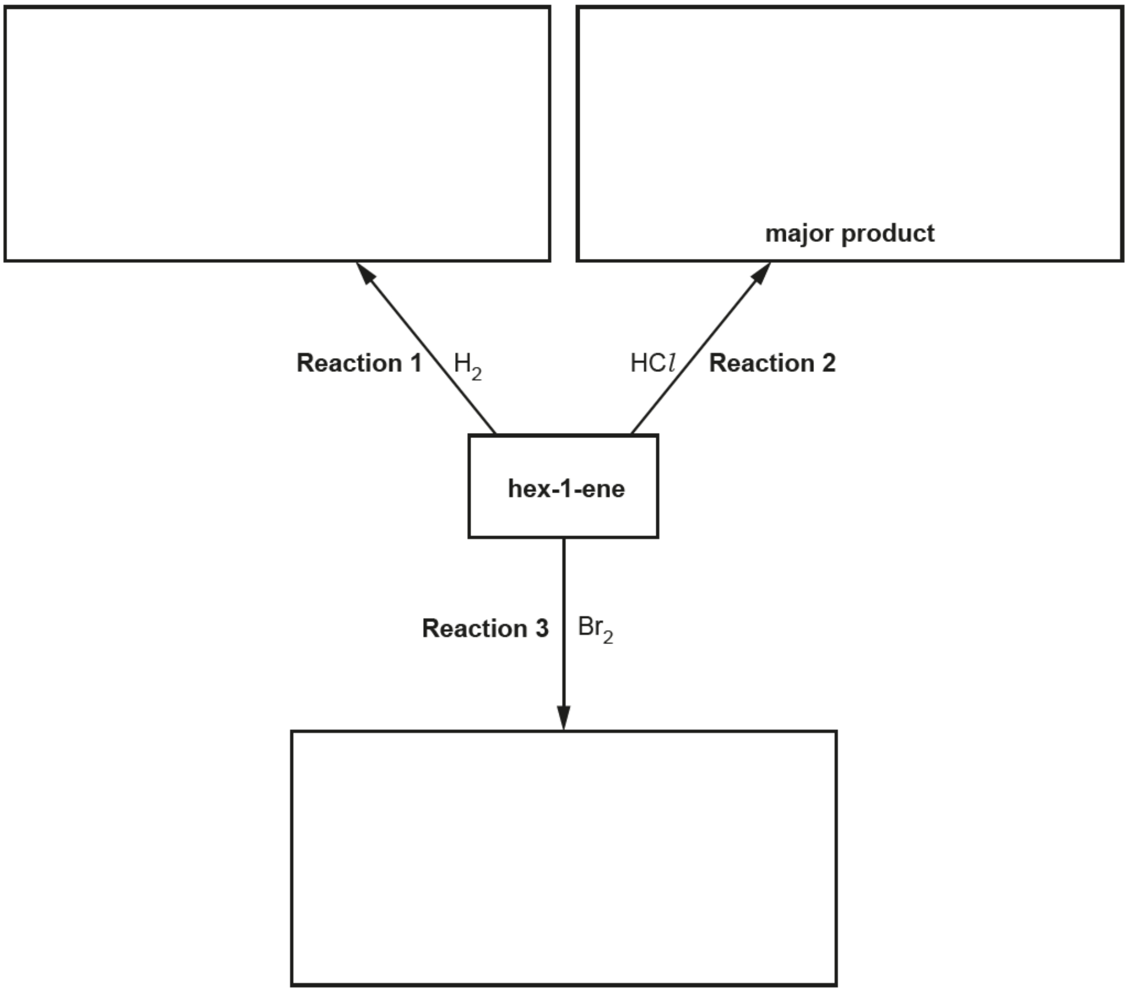
Almost half of the candidates answered this question correctly, the remainder did not realise that the question gave them the answer to the state that the copper sulphate solution was in. Many answers stated that it could be solid or aqueous, so difficult to classify.

Question 5 (a) (i)

5 This question is about hex-1-ene, $CH_3CH_2CH_2CH_2CH{=}CH_2$.

(a) Hex-1-ene is reacted with H_2, HCl and Br_2 as shown in the flowchart below.

(i) Complete the flowchart to show the structures of the organic products of these reactions.



[3]

Most candidates answered this question well and achieved full marks. The most common errors were to put the chlorine on the wrong carbon, or to put both bromines on the same carbon.

Question 5 (a) (ii)

(ii) State the catalyst needed in **reaction 1**.

.... **[1]**

Most candidates correctly stated nickel, although it was spelled incorrectly a lot of the time, which was ignored. "Acid" was the most common incorrect answer

Question 5 (a) (iii)

(iii) What would you observe in **reaction 3**?

....

.... **[1]**

Many candidates wrote the colour change the wrong way around, or thought that a gas would be evolved, or wrote "clear" instead of "colourless". A large proportion merely stated what type of reaction it was, rather than what they would observe.

Question 5 (b) (i)

(b) Hex-1-ene is a liquid with a boiling point of 63 °C and a density of 0.67 g cm^{-3}.

Hex-1-ene can be prepared by refluxing hexan-1-ol (boiling point 157 °C) with an acid catalyst.

Hexan-1-ol is a liquid with a boiling point of 157 °C and a density of 0.82 g cm^{-3}.

The equation is shown below.

After reflux, the resulting mixture contains unreacted hexan-1-ol, hex-1-ene and water. The mixture is then purified.

The expected percentage yield of hex-1-ene from hexan-1-ol is 62.5%.

(i)* A student plans to prepare 4.20 g of hex-1-ene by this method.

Calculate the mass of hexan-1-ol that the student should use and explain how you could obtain pure hex-1-ene from the mixture obtained after reflux. **[6]**

This question discriminated well and most were able to attempt to calculate a mass and explain the purification steps with some fine detail. It was evident that most candidates were aware of the apparatus required but the logic in the order was sometimes out of sequence. Drying agents were mentioned, some of the examples used were incorrect and errors were made with the boiling points if candidates mentioned distillation.

Exemplar 5

% yeild = Actual value / Theoratical value × 100

~~62~~ Moles of 4.20 = 4.20 / 84

= .05

1 mole of alchol forms 1 mole of Hex-1-ene

62.5 = .05 / T.V × 100

T.V = .05 / 62.5 × 100 = .08

Mass of hexan-1-ol = .08 × 102

= 8.16 g of hexan-1-ol.

Obtaing pure hex-1-ene.

First student pour the

Additional answer space if required: Q 5 (b) continued

mixture into separating funnel. Close the top of separating

This in a response of an excellent approach to this question, it was given 6 marks. The correct mass has been calculated and all of the fine detail, except distilling at 63°C

Question 5 (b) (ii)

(ii) Another student suggested that hex-1-ene could be prepared from hexan-2-ol by the same method.

Would you expect the percentage yield of hex-1-ene to be greater than, less than or about the same as when using hexan-1-ol?

Explain your answer.

....

....

....

.... **[2]**

Most candidates obtained the first mark, but very few stated that hex-2-ene forms which is why the yield is less. Many candidates stated this was due to secondary alcohols being more stable than primary ones and a significant number thought the yield would be the same as they had the same M_r.

Question 5 (c) (i)

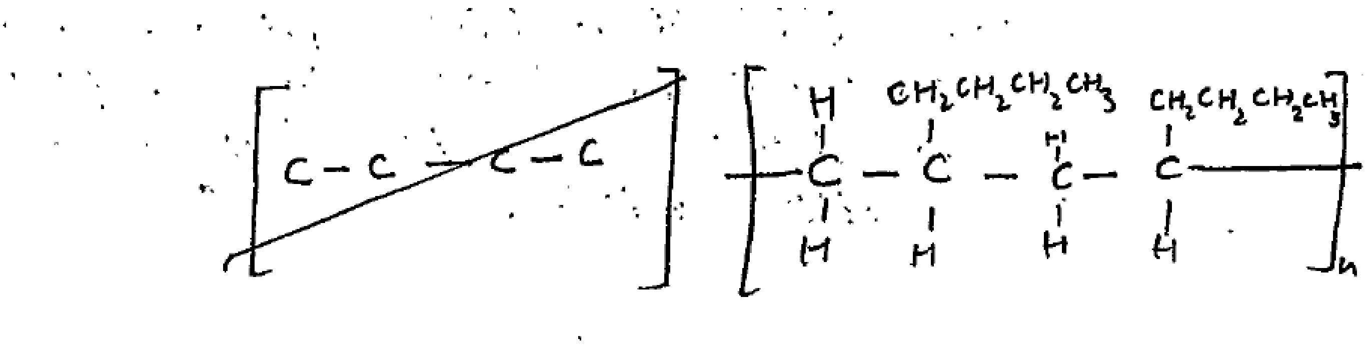
(c) Hex-1-ene can also be polymerised to form poly(hex-1-ene).

(i) Draw a section of poly(hex-1-ene) containing **two** repeat units.

[1]

Over half of the candidates answered this question incorrectly. Many drew the wrong repeat units or did not show two repeat units. The structural diagrams were very hard to decipher and not well drawn.

Exemplar 6



Although the connectivity is not exact, this was allowed. Many students drew full displayed structures which were very difficult to decipher as they often encroached over the writing in the question.

Question 5 (c) (ii)

(ii) Waste poly(hex-1-ene) can be disposed of usefully by recycling.

State **two** other methods of disposing of polymers that can be beneficial to the environment.

1 ....

....

2 ....

.... **[2]**

Most students did not gain many marks on this question, with a significant number stating that the plastics could be used to feed livestock or as fertilisers. Those that mentioned combustion, merely stated plastics could be used as a fuel. Some candidates made references to making them biodegradable or recycling, but these answers were not given.

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