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<td>19</td>
<td></td>
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Introduction

These exemplar answers have been chosen from the summer 2018 examination series.

OCR is open to a wide variety of approaches and all answers are considered on their merits. These exemplars, therefore, should not be seen as the only way to answer questions but do illustrate how the mark scheme has been applied.

Please always refer to the specification [https://www.ocr.org.uk/qualifications/gcse/gateway-science-suite-chemistry-a-j248-from-2016/](https://www.ocr.org.uk/qualifications/gcse/gateway-science-suite-chemistry-a-j248-from-2016/) for full details of the assessment for this qualification. These exemplar answers should also be read in conjunction with the sample assessment materials and the June 2018 Examiners’ report or Report to Centres available from Interchange [https://interchange.ocr.org.uk/Home.mvc/](https://interchange.ocr.org.uk/Home.mvc/)

The question paper, mark scheme and any resource booklet(s) will be available on the OCR website from summer 2019. Until then, they are available on OCR Interchange (school exams officers will have a login for this and are able to set up teachers with specific logins – see the following link for further information [http://www.ocr.org.uk/administration/support-and-tools/interchange/managing-user-accounts/](http://www.ocr.org.uk/administration/support-and-tools/interchange/managing-user-accounts/)).

It is important to note that approaches to question setting and marking will remain consistent. At the same time OCR reviews all its qualifications annually and may make small adjustments to improve the performance of its assessments. We will let you know of any substantive changes.
Question 7

Exemplar 1  

0 marks

7. Look at the equation for a reversible reaction.

$$4\text{NH}_3(g) + 5\text{O}_2(g) \rightleftharpoons 4\text{NO}(g) + 6\text{H}_2\text{O}(g) \quad \Delta H = -950 \text{kJ mol}^{-1}$$

The reversible reaction forms a dynamic equilibrium in a sealed container.

Which of the following would move the position of equilibrium to the right?

A. Decreasing the pressure and decreasing the temperature.
B. Increasing the pressure and decreasing the temperature.
C. Increasing the pressure and increasing the temperature.
D. Increasing the pressure and using a catalyst.

Your answer: B

[1]

Examiner commentary

This is an exothermic reaction, $\Delta H$ is negative. The equilibrium can be moved to the right by decreasing the temperature.

All of the species in the reaction are gases and so subject to changes in pressure. There are 9 moles of gaseous reactants and 10 moles of gaseous products. The equilibrium can be moved to the right by decreasing the pressure.

A is the correct response, no mark is credited for B, which was a common incorrect response.
Question 11

Exemplar 1  1 mark

11 How much $0.2 \text{ mol/dm}^3$ hydrochloric acid solution could you make from $100 \text{ cm}^3$ of $1.0 \text{ mol/dm}^3$ hydrochloric acid?

A 20 cm$^3$
B 200 cm$^3$
C 500 cm$^3$
D 600 cm$^3$

Your answer [C] [1]

Examiner commentary

The number of moles must be the same before and after dilution.

The starting solution contains 0.1 moles.

The final solution must contain 0.1 moles and be of concentration $0.2 \text{ mol/dm}^3$, which means the new volume would be 500 cm$^3$.

The correct response is C, the mark is credited.

B was a popular incorrect response with candidates mistaking 0.2 as being twice 1, and then incorrectly doubling the volume.
Question 14

Exemplar 1

1 mark

14. A gas chromatogram is a chart that represents different substances in a mixture.

Which of the following statements about a gas chromatogram is not correct?

A. A gas chromatogram can detect very small amounts of substances.
B. One compound produces several peaks.
C. The area of each peak shows the relative amount of each substance.
D. The retention time is different for different substances.

Your answer: B

Examiner commentary

A gas chromatogram can detect very small amounts of substances, response A is correct.

The area of the peak in a gas chromatogram shows the relative amounts of each substance, response C is correct.

The retention time in gas chromatography is different for different substances, response D is correct.

Gas chromatography is used to separate and identify substances which do not decompose when vaporised. Hence a compound will only give one peak in the chromatogram, response B is incorrect.

Candidate chooses response B as being the incorrect response, the mark is credited.

This response shows that the candidate has considered each option and indicated the correct statements with a tick so leaving the incorrect statement so finding the answer.


**Question 16(a)**

**Exemplar 1**

16. This question is about life-cycle assessment.

(a) A car company is developing three new cars:
   - A petrol car.
   - A diesel car.
   - An electric car.

They do a life-cycle assessment of each car.

Look at the information about the life-cycle assessment of each car.

<table>
<thead>
<tr>
<th>Energy needed to make it</th>
<th>Electric car</th>
<th>Diesel car</th>
<th>Petrol car</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative amount</td>
<td>80</td>
<td>100</td>
<td>120</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Amount of global warming</th>
<th>Electric car</th>
<th>Diesel car</th>
<th>Petrol car</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative amount</td>
<td>60</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Amount of acid rain made</th>
<th>Electric car</th>
<th>Diesel car</th>
<th>Petrol car</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative amount</td>
<td>40</td>
<td>60</td>
<td>80</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Amount of water pollution</th>
<th>Electric car</th>
<th>Diesel car</th>
<th>Petrol car</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative amount</td>
<td>20</td>
<td>40</td>
<td>60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Amount of ozone made</th>
<th>Electric car</th>
<th>Diesel car</th>
<th>Petrol car</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative amount</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
</tbody>
</table>

The company decides to manufacture and sell the electric car.

Explain why they make this choice.

Use the information from the life-cycle assessment to help you.

- overall, the electric car is better for the environment.
- it will cause the least amount of global warming and ozone.

The least energy required. \[3\]

**Examiner commentary**

Candidates needed to use the data to compare the electric car to diesel and petrol cars. Since the data is given in the question specific answers will be required, vague generalisations will not be creditworthy. The question is worth 3 marks which indicates that there needs to be three comparisons.

- Least amount of global warming caused, marking point 2 is credited.
- Least amount of ozone caused, marking point 3 is credited.
- Least amount of energy required, marking point 1 is credited.
Question 16(b)

Exemplar 1

3 marks

(b) The fuels for petrol and diesel cars are made from crude oil.

Crude oil is separated into different parts by **fractional distillation**.

The diagram shows a fractionating column.

Fractions

- LPG
- Petrol
- Paraffin
- Diesel
- Heating oil
- Fuel oil
- Bitumen

Heated crude oil vapour

Explain why crude oil vapour can be separated by fractional distillation.

It can be separated because it contains different fractions that are different sizes. The longer chain molecules have higher boiling and melting points because they require more energy to break the intermolecular forces so they are extracted first further down. The shorter chain molecules have lower boiling and melting points as they require less energy to break their intermolecular forces. Therefore, they are collected further up where it is coolest.

Examiner commentary

This candidate can be credited 2 marks from the first section of marks and one from the second section of marks OR one from the first section of marks and two from the second section of marks.

Candidate discusses longer chain molecules and shorter chain molecules in crude oil, marking point 2 can be credited. The difference in boiling points of these fractions is discussed, marking point 3 can be credited.

The candidate then explains that larger molecules have higher boiling points, marking point 5 can be credited. They then explain that larger molecules have stronger intermolecular forces, marking point 6 can be credited.
Exemplar 2

2 marks

(b) The fuels for the petrol and diesel cars are made from crude oil.

Crude oil is separated into different parts by **fractional distillation**.

The diagram shows a fractionating column.

Explain why crude oil vapour can be separated by fractional distillation.

Each substance in crude oil has a different boiling point. This means you can use a temperature gradient to separate the impurities into fractionating columns and allow the substances to condense and collect from the one liquid due to their different boiling points. [3]

Examiner commentary

The candidate appreciates that each substance in crude oil has a different boiling point, marking point 3 is credited.

The temperature gradient in the column is discussed, marking point 1 is credited.

There are no points from the second section of marks included in the answer, no further marks are credited.

Lower ability candidates were rarely credited marks from the second (explanation) section of marking points.
Question 16(c)

Exemplar 1

0 marks

(c) The table shows the boiling points of molecules present in different crude oil fractions.

<table>
<thead>
<tr>
<th>Molecule</th>
<th>Boiling point (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-2</td>
</tr>
<tr>
<td>B</td>
<td>125</td>
</tr>
<tr>
<td>C</td>
<td>216</td>
</tr>
<tr>
<td>D</td>
<td>502</td>
</tr>
</tbody>
</table>

Which molecule, A, B, C or D is in the LPG fraction?

Explain your decision.

D as it has the highest boiling point ...

........................................................................................................................................ [2]

Examiner commentary

LPG is a gas, it contains molecule A as this has the lowest boiling point.

This candidate has chosen molecule D because it has the highest boiling point, no marks are credited.
Question 16(d)

Exemplar 1

3 marks

(d) Car manufacturers are developing cars that are powered by hydrogen/oxygen fuel cells.

The table shows some information about a 200 km journey using an electric car and a car using a fuel cell.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Electric</th>
<th>Fuel cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refuelling time (minutes)</td>
<td>360</td>
<td>4</td>
</tr>
<tr>
<td>Cost of refuelling (£)</td>
<td>3.20</td>
<td>4.20</td>
</tr>
<tr>
<td>CO₂ emitted (kg)</td>
<td>48</td>
<td>36</td>
</tr>
<tr>
<td>Mass of car (kg)</td>
<td>1550</td>
<td>1200</td>
</tr>
</tbody>
</table>

Evaluate the advantages and disadvantages of using a car powered by a fuel cell, rather than an electric car for the 200 km journey.

...The advantage of using a car powered by a fuel cell is that it emits less CO₂, it doesn’t take as long as an electric car to charge (4 minutes) and it is lighter. However, it does cost more to refuel than an electric car. [3]

Examiner commentary

Candidates needed to use the data to compare the electric car to the car using a fuel cell, simply stating the data for one of the cars is not a comparison and so is not creditworthy. The question is worth 3 marks which indicates that there needs to be three comparisons, from the data given there should be any two advantages from the three in the data and one disadvantage.

Fuel cell emits less carbon dioxide is credited marking point 2.

Recharging the fuel cell takes less time is credited marking point 1.

Fuel cell costs more to refuel is credited marking point 4.
Question 17(a)

Exemplar 1

2 marks

A student is using the internet to find out about alcohols. The student finds the following information.

<table>
<thead>
<tr>
<th>Name</th>
<th>Number of carbon atoms</th>
<th>Boiling point (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methanol</td>
<td>1</td>
<td>65</td>
</tr>
<tr>
<td>Ethanol</td>
<td>2</td>
<td>79</td>
</tr>
<tr>
<td>Propanol</td>
<td>3</td>
<td>97</td>
</tr>
<tr>
<td>Pentanol</td>
<td>5</td>
<td>138</td>
</tr>
<tr>
<td>Hexanol</td>
<td>6</td>
<td>156</td>
</tr>
</tbody>
</table>

(a) Plot a graph of the boiling points of the alcohols on the grid. Draw a line of best fit.
Examiner commentary

The point for pentanol with 5 carbons is greater than ½ small square away from 138, only one of the 2 marks available for plotting the points is credited.

The line of best-fit is condoned, marking point 3 is credited.
Question 17(b)(i)

Exemplar 1  

(b) (i) The student could not find a value for the boiling point of butanol, C₄H₉OH.

Use the graph to estimate the boiling point of butanol.

Answer = .......... °C [1]

Examiner commentary

The value is read from the line the candidate has drawn and so is unique to that candidate’s graph.

The value from this graph is between 118 and 120 °C, the mark is not credited.
Question 17(b)(ii)

Exemplar 1

(ii) Draw the displayed formula of butanol, C₄H₉OH.

[Image of the displayed formula of butanol]

Examiner commentary
A displayed formula should show all of the atoms and all of the bonds, the marking point is credited.

Exemplar 2

(ii) Draw the displayed formula of butanol, C₄H₉OH.

[Image of the displayed formula of butanol]

Examiner commentary
The formula shows C bonded to H bonded to O, this is incorrect and the marking point is not credited. This was a common error.
**Question 17(d)**

**Exemplar 1**

0 marks

(d) Ethanol, \( \text{C}_2\text{H}_5\text{OH} \), can be oxidised to **ethanoic acid** using potassium manganate(VII).

What is the formula of ethanoic acid?

\[
\text{C}_2\text{H}_3\text{COOH} \]

[1]

**Examiner commentary**

\( \text{C}_2\text{H}_3\text{COOH} \) contains three carbons and is the formula of propanoic acid, the marking point is not credited.
This was a common incorrect response.

---

**Question 18(a)**

**Exemplar 1**

1 mark

18 A student investigates the reaction between marble chips, \( \text{CaCO}_3 \), and hydrochloric acid.

Calcium chloride, \( \text{CaCl}_2 \), carbon dioxide and water are made.

(a) Write a balanced symbol equation for the reaction.

\[
\text{CaCO}_3 (\text{s}) + 2\text{HCl} (\text{aq}) \rightarrow \text{CaCl}_2 (\text{aq}) + \text{CO}_2 (\text{g}) + \text{H}_2\text{O} (\text{l})
\]

**Examiner commentary**

The individual species are correct, marking point 1 is credited.

The balancing is incorrect, marking point 2 is not credited. A doubling of all of the species would have been correct.

---

**Exemplar 2**

0 marks

18 A student investigates the reaction between marble chips, \( \text{CaCO}_3 \), and hydrochloric acid.

Calcium chloride, \( \text{CaCl}_2 \), carbon dioxide and water are made.

(a) Write a balanced symbol equation for the reaction.

\[
\text{CaCO}_3 + \text{H}_2\text{Cl}_2 \rightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}
\]

**Examiner commentary**

The candidate has attempted to balance the equation but has changed the formula of the hydrochloric acid. Marking point 2 cannot be credited if marking point 1 has not been credited. This answer is credited no marks.
**Question 18(b)(ii)**

**Exemplar 1**

(ii) Look at the line for experiment C.

Calculate the rate of reaction during the first 45 seconds.

Give your answer to 2 significant figures.

\[
\frac{20 \text{ cm}^3}{45 \text{ secs}} = 0.4 \text{ cm}^3/\text{sec}
\]

Answer = .................................. cm³/s [3]

**Examiner commentary**

The calculation \(20 ÷ 45\) is correct, marking point 1 is credited.

The evaluation of the calculation is correct, 0.4 recurring, marking point 2 is credited.

The answer is only given to one significant figure, 0.4, but the question asked for two significant figures, 0.44. Marking point 3 is not credited.
Question 18(c)

Exemplar 1

2 marks

Examiner commentary

The candidate has fewer particles in the dilute acid but has not explained that these particles are in the same volume, marking point 1 is not credited.

The candidate has less collisions but these are not in the same time or less frequent, marking point 2 is not credited.

At a lower temperature the particles have less energy, marking point 3 is credited.

Which gives rise to less successful collisions, marking point 5 is credited.
Question 18(d)(i)

Exemplar 1  

1 mark

(d) A catalyst can be used to increase the rate of a reaction.

Look at the energy profile diagram for a reaction without a catalyst.

<table>
<thead>
<tr>
<th>Energy</th>
<th>Reactants</th>
<th>Uncatalysed reaction</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>less activation energy</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>less energy required</td>
<td></td>
</tr>
</tbody>
</table>

Progress of reaction

Complete the energy profile diagram to show

(i) The reaction profile for the reaction with a catalyst.  

Examiner commentary

The catalysed reaction profile has a lower activation energy, the marking point is credited.

(This answer was also credited the mark for 18dii, an arrow upwards from the reactants to the top of the activation energy.)
Question 18(d)(ii)

Exemplar 1

(ii) Label the activation energy for the reaction with a catalyst. [1]

Examiner commentary

The activation energy is labelled with a double headed arrow instead of an arrow upwards, the marking point is not credited.

(This answer was credited the mark for 18di, the profile with a lower activation energy is drawn.)
Exemplar 1

19* Ethanol is manufactured by reacting ethene, C₂H₄, with steam.

The reaction is reversible and occurs in a closed system.

\[
\text{C}_2\text{H}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{C}_2\text{H}_5\text{OH}(\text{g}) \quad \Delta H = -45 \text{ kJ mol}^{-1}
\]

Only 5% of the ethene is converted into ethanol at each pass through the reactor.

By removing the ethanol from the equilibrium mixture and recycling the ethene, it is possible to achieve an overall 95% conversion:

![Diagram of the process]

**Explain why the conditions used for the process are chosen.**

L3 A compromise temperature of 300°C is chosen because the forward reaction is exothermic. This means a lower temperature would shift the equilibrium position to the left. This is because of the **Chattelier's principle** which states that the position would change to counteract the change. However, a low temperature would mean the rate is too low, so a compromise temperature is used.

A **catalyst** is used to decrease the activation energy and increase the rate.

A high pressure of 60-70 atm is used because they are less reactive and are more likely to react in the products. Therefore, increasing the pressure shifts the equilibrium position to the right. This is because of the **Chattelier's principle**. This increases the percentage yield. A higher pressure isn't used because it would be too **uneconomical** — expensive. 

---

[6]
Examiner commentary

The candidate has analysed the information and applied knowledge of Le Chatelier’s principle to explain the conditions used in the manufacture of ethanol. The candidate has clearly explained how 300°C is a compromise between rate of reaction and position of equilibrium; and that 60-70 atm is a compromise between position of equilibrium and cost. They appreciate that the phosphoric acid catalyst increases the rate of the reaction.

This is a Level 3 response, 6 marks are credited.

Exemplar 2 Level 2, 3 marks

Explain why the conditions used for the process are chosen.

[6]

It needs to be a closed system so that no substances can escape from the system and none can enter. This means the reactants are more likely to form the worked product. By removing the ethanol, you are disrupting the dynamic equilibrium of the reaction. This means the reaction will shift to oppose the change and favour the forward reactions. This means more of the desired product (ethanol) is made.

Examiner commentary

The candidate has explained the importance of a closed system, has identified how removing ethanol from the reaction will affect the equilibrium and has explained this in terms of Le Chatelier.

This is a Level 2 response, 3 marks are credited.

To be credited higher marks some of temperature, pressure and catalyst need to be included in the answer.
Exemplar Candidate Work

Exemplar 3

Level 1, 2 marks

Explain why the conditions used for the process are chosen.

A catalyst... is an enzyme that will work best at its optimum temperature. If the temperature was lower, it wouldn’t work as well, and if it was higher, it would denature. In this case, 300°C is the optimum temperature for phosphoric (V) acid. Additionally, using higher temperatures is costing to the manufacturer and dangerous to the workers. Having the pressure at 60-70 atm means the rate of reaction will not be too slow; however, if it was increased, it would go faster. Although, it would be dangerous to do so. By recycling the unreacted gases, it is ensuring there is not much waste and achieving a 95% conversion. Furthermore, changing the conditions would also change the equilibrium, which may affect the whole process.

Examiner commentary

The candidate has discussed the effect of pressure on rate and safety and that high temperatures are costly and less safe. There is a mention of changing conditions changing equilibrium, but no specifics are included.

This is a Level 1 answer, 2 marks are credited.
20 Student A does a titration with an acid and an alkali.

He uses dilute sulfuric acid, sodium hydroxide solution and an indicator solution.

The diagram shows the apparatus he uses.

The student adds sodium hydroxide solution from the burette to the sulfuric acid until the indicator changes colour.

He then adds a few more drops of sodium hydroxide to be certain the sulfuric acid is neutralised.

He takes the final volume reading on the burette to find out how much acid reacts with 25.0 cm³ of sodium hydroxide solution.

(a) Describe and explain how the student could improve his experiment to get a more accurate value.

He should not add any extra drop of alkali.

He should perform two or three trials to ensure a consistent result.

He should note the reading on the burette and then add it to the beaker as it will make the result more accurate. [4]
Examiner commentary

The candidate has appreciated that extra sodium hydroxide should not be added but does not explain why, marking point 1 is credited.

The candidate swirls the flask and explains that this is to ensure that it all reacts, marking points 7 and 8 are credited.

Exemplar 2

2 marks

The student adds sodium hydroxide solution from the burette to the sulfuric acid until the indicator changes colour.

He then adds a few more drops of sodium hydroxide to be certain the sulfuric acid is neutralised.

He takes the final volume reading on the burette to find out how much acid reacts with 25.0 cm³ of sodium hydroxide solution.

(a) Describe and explain how the student could improve his experiment to get a more accurate value.

The indicator the student uses could be phenolphthalein or methyl orange. The student can notice an abrupt change in pH through the colour change rather than a gradual one. He can do the experiment multiple times so they can disregard any anomalies and work out an average mean.

Examiner commentary

The candidate has chosen two single indicators rather than a mixed indicator and explained that either of these will give an abrupt colour change rather than a gradual one. Marking points 5 and 6 are credited.
Question 20(d)(i)

Exemplar 1

0 marks

(d) Student B does another experiment.

This time she uses:

- 20.0 cm³ of dilute hydrochloric acid in the beaker
- sodium hydroxide solution of concentration 0.200 mol/dm³ in the burette.

Look at student B’s results.

<table>
<thead>
<tr>
<th>Titration number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final burette reading (cm³)</td>
<td>26.9</td>
<td>27.6</td>
<td>27.0</td>
<td>28.2</td>
</tr>
<tr>
<td>Initial burette reading (cm³)</td>
<td>0.5</td>
<td>2.5</td>
<td>1.2</td>
<td>3.2</td>
</tr>
<tr>
<td>Titre (volume of alkali used) (cm³)</td>
<td>26.4</td>
<td>25.1</td>
<td>25.8</td>
<td>25.0</td>
</tr>
</tbody>
</table>

(i) Student B decides to only use the results from titration numbers 2 and 4.

Explain why.

The results for initial burette reading for titrations 1 and 3 are anomalously high and when used with the other values create inaccurate results. [1]

Examiner commentary

The candidate has compared the initial burette readings rather than the volume of the titre (the volume of alkali used in the titration), the marking point is not credited.
Question 20(d)(ii)

Exemplar 1

3 marks

(ii) Look at the equation for the reaction between hydrochloric acid, HCl, and sodium hydroxide, NaOH.

\[ \text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O} \]

Calculate the concentration of hydrochloric acid in mol/dm\(^3\).

Use the average titre, in cm\(^3\), from titration numbers 2 and 4.

Give your answer to 2 significant figures.

\[ \frac{25.1 + 25.0}{2} = 25.05 \text{ cm}^3 \]

\[ \frac{25.05}{1000} = 0.02505 \text{ dm}^3 \]

Answer = ........................................ mol/dm\(^3\) [4]

Examiner commentary

The candidate has calculated the average titre incorrectly, marking point 1 is not credited.

The number of moles of sodium hydroxide is not calculated correctly, marking point 2 is not credited.

However, the concentration of the solution using the candidate’s values has been calculated correctly, the earlier erroneous value is carried forward through the calculation, marking point 3 is credited.

The final answer is quoted to two significant figures, marking point 4 is credited.

This is an example of the importance of candidates showing clearly all of the steps in their working, if an error is made the candidate is not credited the mark for that step but the marks for the rest of the steps are still available if that erroneous value is used correctly.
Question 21(a)(i)

Exemplar 1

21 (a) A student dissolves 0.6 g of zinc sulfate in 250 cm\(^3\) of water.

(i) Calculate the volume of the water in dm\(^3\).

\[
\frac{250 \text{ cm}^3}{10} = 25
\]

Answer = ......................... dm\(^3\) [1]

Examiner commentary

The candidate believes that there are 10 cm\(^3\) in 1 dm\(^3\), hence division by 10, marking point is not credited.

Some candidates appreciated that there are 1000 cm\(^3\) in 1 dm\(^3\), but then multiplied by 1000 instead of dividing.

Question 21(a)(ii)

Exemplar 1

(ii) Use your answer to part (a)(i) to help you calculate the concentration of the zinc sulfate in g/dm\(^3\).

\[
0.6 \text{ g} \div 25 \text{ dm}^3 = 0.024 \text{ g/dm}^3
\]

Answer = ......................... g/dm\(^3\) [1]

Examiner commentary

The expected answer is 2.4. The candidate does not have this answer and so the answer to 21ai needs to be consulted.

The candidate has 25 as their answer to 21ai. They then use this value correctly, 0.6 ÷ 25 = 0.024, the marking point is credited.

This is an example of an incorrect answer from one step being used correctly in the second step, the mark is credited as an error carried forward.


**Question 21(b)(i)**

**Exemplar 1**

1 mark

(b) Zinc reacts with sulfuric acid. Zinc sulfate and hydrogen gas, H₂, are made.

\[
\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{H}_2
\]

(i) Calculate the amount of hydrogen gas, in mol, that could be made from 3.27 g of zinc.

\[
\text{mol} = \frac{3.27 \times (65.4 + 32.1 \times 4 \times 16)}{65.4 + 32.1} \approx 0.1 \text{ mol}
\]

**Examiner commentary**

The first step, 3.27 ÷ 65.4, is correct. Marking point 1 is credited. The candidate then multiplies the answer to step one by 2, marking point 2 is not credited. This was quite a common error.

**Question 21(b)(ii)**

**Exemplar 1**

2 marks

(ii) Use your answer to part (b)(i) to calculate the volume of hydrogen gas produced at room temperature and pressure.

One mole of any gas occupies 24 dm³ at room temperature and pressure.

\[0.1 \text{ mol} \times 24 \text{ dm}^3 = 2.4 \text{ dm}^3\]

**Examiner commentary**

The expected answer is 1.2, the candidate does not have this answer and so the answer to 21bi needs to be consulted. The candidate has 0.1 as their answer to 21bi. They then use this value correctly, 0.1 x 24 = 2.4, the marking point is credited. This is another example of an incorrect answer from one step being used correctly in the second step, the mark is credited as an error carried forward.
Question 21(c)(i)

Exemplar 1 3 marks

(c) Hydrogen can be made by reacting methane with steam.

\[
\text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO} + 3\text{H}_2
\]

The atom economy for this process is 17.6%.

Hydrogen can also be produced by the decomposition of ammonia.

This reaction requires a catalyst.

\[2\text{NH}_3 \rightarrow \text{N}_2 + 3\text{H}_2\]

(i) Calculate the atom economy for the production of hydrogen from ammonia.

Give your answer to 3 significant figures.

\[
\frac{3 \times 2}{2 \times 1 + 3 	imes 2} = \frac{6}{84} \times 100 = 17.6
\]

Answer = \boxed{17.6} \% [3]

Examiner commentary

The correct answer to 3 significant figures is on the answer line, 3 marks are credited.

Exemplar 2 2 marks

(c) Hydrogen can be made by reacting methane with steam.

\[
\text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO} + 3\text{H}_2
\]

The atom economy for this process is 17.6%.

Hydrogen can also be produced by the decomposition of ammonia.

This reaction requires a catalyst.

\[2\text{NH}_3 \rightarrow \text{N}_2 + 3\text{H}_2\]

(i) Calculate the atom economy for the production of hydrogen from ammonia.

Give your answer to 3 significant figures.

\[
\begin{align*}
2 \times \text{N} &= 28 \\
6 \times \text{H} &= 6
\end{align*}
\]

\[
\frac{28}{34} \times 100 = \frac{51.8}{6%
\]

Answer = \boxed{51.8} \% [3]

Examiner commentary

17.6 is incorrect, marking point 1 is not credited.

The calculation using this 17.6 is correct and is evaluated correctly, marking point 2 is credited.

The answer is given to 3 significant figures, marking point 3 is credited.
Question 21(c)(ii)

Exemplar 1 3 marks

(ii) Suggest other factors, apart from atom economy, that must be considered when deciding which reaction pathway to choose for the manufacture of hydrogen.

The maximisation of the rate of reaction, the usefulness of the reactants and the percentage yield. ................................................................. [3]

Examiner commentary

The candidate has given three correct factors, rate of reaction is credited marking point 3, usefulness of by-products is credited marking point 2 and percentage yield is credited marking point 1.

Exemplar 2 1 mark

(ii) Suggest other factors, apart from atom economy, that must be considered when deciding which reaction pathway to choose for the manufacture of hydrogen.

Cost of production, efficiency, toxicity, availability of reactants, danger, atom economy, percentage yield. ......................................................................................................................... [3]

Examiner commentary

The candidate has given one specific factor, percentage yield, marking point 1 is credited.

Vague statements such as cost and toxicity are not creditworthy, the answer needs to be specific e.g. cost of the raw materials.

Atom economy is not creditworthy since the question asks for other factors.
Question 22(c)

Exemplar 1  

1 mark

(c) Butene undergoes addition polymerisation to form poly(butene).

Write the displayed formulae, for poly(butene).

\[
\begin{align*}
\text{[2]} \\
\text{Examiner commentary} \\
\text{The displayed formula is correct, including the extension bonds, marking point 1 is credited.} \\
\text{The brackets are correct but } n \text{ is missing, marking point 2 is not credited.}
\end{align*}
\]

Exemplar 2  

0 marks

(c) Butene undergoes addition polymerisation to form poly(butene).

Write the displayed formulae, for poly(butene).

\[
\begin{align*}
\text{[2]} \\
\text{Examiner commentary} \\
\text{The candidate has drawn poly(ethene), no marks are credited. This was a common error.}
\end{align*}
\]
Question 22(e)(ii)

Exemplar 1

(ii) Polyesters are made from a carboxylic acid and an alcohol.

Complete the block diagram to show the formation of a polyester.

Examiner commentary

The structure has a correct ester linkage, marking point 1 is credited.

The formula has an extra O at the left hand side (the rest of the structure is correct), marking point 2 is not credited.
Question 22(f)(i) 3 marks

(f) Nylon is another polymer formed in a condensation polymerisation reaction.

Nylon can be made from hexanediol dichloride and hexane-1,6-diamine.

Both chemicals are highly corrosive.

A solvent is needed which is highly flammable.

(i) Describe how to make nylon in a laboratory.


Examiner commentary

The candidate is pouring one solution on top of the other, marking point 1 is credited.

Nylon is made at the interface is credited marking point 3.

The nylon being lifted and drawn out is credited marking point 4.
Question 22(f)(ii)

Exemplar 1

(II) Describe and explain three precautions needed to control the hazards in this experiment.

- Wear gloves to protect hands from corrosive substances.
- Wear goggles to protect eyes from corrosive substances.
- Use a water bath to prevent the ignition of flammable substance. [3]

Examiner commentary

The candidate has used the safety information in the question to describe and explain the safety precautions required.

Gloves to protect hands from corrosive substances is credited marking point 2.

Goggles to protect eyes from corrosive substances is credited marking point 3.

Using a water bath to prevent ignition of flammable substance is credited marking point 1.

It was common for candidates to list safety precautions such as goggles and gloves without explaining them and so not being credited the marks.
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