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Examiners' report

GATEWAY SCIENCE CHEMISTRY A

J248

For first teaching in 2016

J248/04 Summer 2022 series

Version 1

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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. A selection of candidate answers are also provided. 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 and the mark scheme can be downloaded from OCR.

Advance Information for Summer 2022 assessments

To support student revision, advance information was published about the focus of exams for Summer 2022 assessments. Advance information was available for most GCSE, AS and A Level subjects, Core Maths, FSMQ, and Cambridge Nationals Information Technologies. You can find more information on our website.

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Paper 4 series overview

J248/04 is the second of two examination components for candidates entered for the Higher Tier of the new revised GCSE examination for Gateway Science Chemistry A. This unit assesses teaching topics C4-C6, with assumed knowledge of topics C1-C3, and is 50% of the total GCSE. To do well on this paper, candidates need to demonstrate knowledge and understanding of scientific ideas, techniques and procedures across all three topics. They need to be able to apply their knowledge and understanding to unfamiliar contexts as well as displaying the ability to analyse information. Candidates also need to be familiar with a range of experimental procedures and be able to think about how an experimental method could be improved.

J248/04 has an equal emphasis on knowledge and understanding of the assessment outcomes from the specification and application of this knowledge. There are fewer questions which assess analysis of information and ideas.

Centres had clearly worked hard to prepare candidates for this examination, and this was reflected in the low question omit rate.

There was a significant number of marks on this paper for chemical calculations. The mark scheme gave marks in all calculations for error carried forward. However, it was only possible for examiners to award error carried forward when the candidate set out their working clearly, which was often not the case. Centres should also encourage candidates to set out their working to calculations clearly. 'Signposting' of calculations was often poor, with numbers written at random in the answer space. This makes it difficult for the examiner to seek out mark-worthy points and/or award marks for errors carried forward. Equally, for candidates, it often leads to them getting 'lost' going through the calculation.

Centres should remind candidates that if they continue an answer outside of the answer space, they need to clearly indicated that their answer is continued elsewhere. Candidates should be encouraged to use the extra answer pages at the end of the exam paper rather than writing 'randomly' at the bottom of a page.

Candidates who did well on this paper generally did the following:	**Candidates who did less well on this paper generally did the following:**
• Performed standard calculations following the required rubric (e.g. clear working, components and, where needed, significant figures) relating to moles and gas volumes: 18(g)(ii), % yield and yields in reactions: 19(a) & 21(c), atom economy: 20 and titrations: 22(a)(iv). • Produced a clear, concise and well-structured answer for the Level of Response Question: 20. • Understood how to identify the products of chemical reactions: 17(a) – (d), & 22(b). • Applied knowledge and understanding to questions set in a novel context.	• Found it difficult to apply what they had learnt to unfamiliar situations. • Found it difficult to analyse data and then make a judgement, or draw a conclusion, in relation to the data, e.g. 16(c) & 19(b). • Showed imprecise use of scientific terminology, e.g. 18(d), 21(a), 21(b)(i), 22(a)(ii), 22(a)(iii) & 23(c). • Were unable to apply quantitative skills to perform chemical calculations and/or did not organise their responses to quantitative calculations in a clear or structured way.

Section A overview

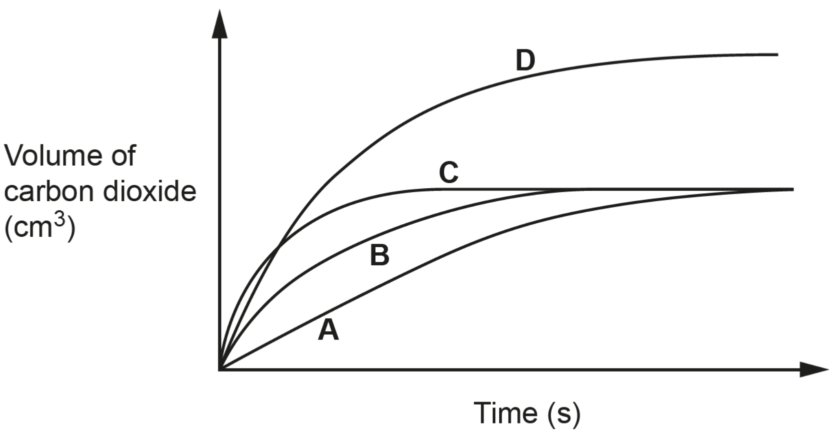
Questions 3, 4, 8, 10, 11 and 15 in this section proved to be good discriminators with many higher attaining candidates answering correctly. Questions 1, 2, 5, 6, 7 and 13 were answered well by candidates with many correct answers.

Question 9

9 A student reacts dilute hydrochloric acid with marble chips. Carbon dioxide gas is made.

- The student repeats the experiment with different size marble chips.
- They use 20 g of marble chips in each experiment.

The graph shows the student's results



Which line shows the result for the **smallest** marble chips?

Your answer ☐ **[1]**

Misconception

D was a common misconception in this question, with candidates thinking that smaller marble chips would produce more carbon dioxide gas, rather than identifying C as the line with the steepest gradient, so the fastest rate of reaction.

Question 12

12 Which type of material is glass?

A Alloy

B Ceramic

C Composite

D Polymer

Your answer ☐ **[1]**

The nature of glass as a ceramic material was only known by the more successful candidates with many identifying glass as either an alloy or a composite.

Question 14

14 The actual yield in a reaction is often less than the predicted yield.

Why?

A One reactant is in excess.

B One reactant is the limiting reactant.

C The reaction has an atom economy of less than 100%.

D The reaction is reversible and does not go to completion.

Your answer ☐ **[1]**

Only the higher attaining candidates correctly answered D, with examiners seeing all possible incorrect answers.

Section B

Question 16 (a)

16 Hydrogen peroxide, H_2O_2, is used as a source of oxygen gas.

Hydrogen peroxide decomposes to make oxygen gas, O_2, and water.

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

.... **[2]**

Most candidates were able to write the correct balanced symbol equation for the decomposition of hydrogen peroxide. 1 mark was given for the correct reactants and products and 1 mark for the correct balancing. The balancing mark was dependent on the correct formulae, but 1 mark was allowed for a balanced equation with minor errors in subscripts or formulae. For example, $2H_2O_2 \rightarrow O_2 + 2h_2O$, would gain 1 mark. When candidates did not gain marks, it was often because they did not balance the equation. Some candidates wrote the equation the wrong way round, i.e. $O_2 + 2H_2O \rightarrow 2H_2O_2$.

Question 16 (b)

(b) The decomposition of hydrogen peroxide is very slow at room temperature. The reaction can be speeded up by adding a catalyst.

- A student investigates the decomposition of hydrogen peroxide using two different catalysts, **A** and **B**.
- The student uses 50 cm^3 of hydrogen peroxide and 0.5 g of the catalyst in each experiment.

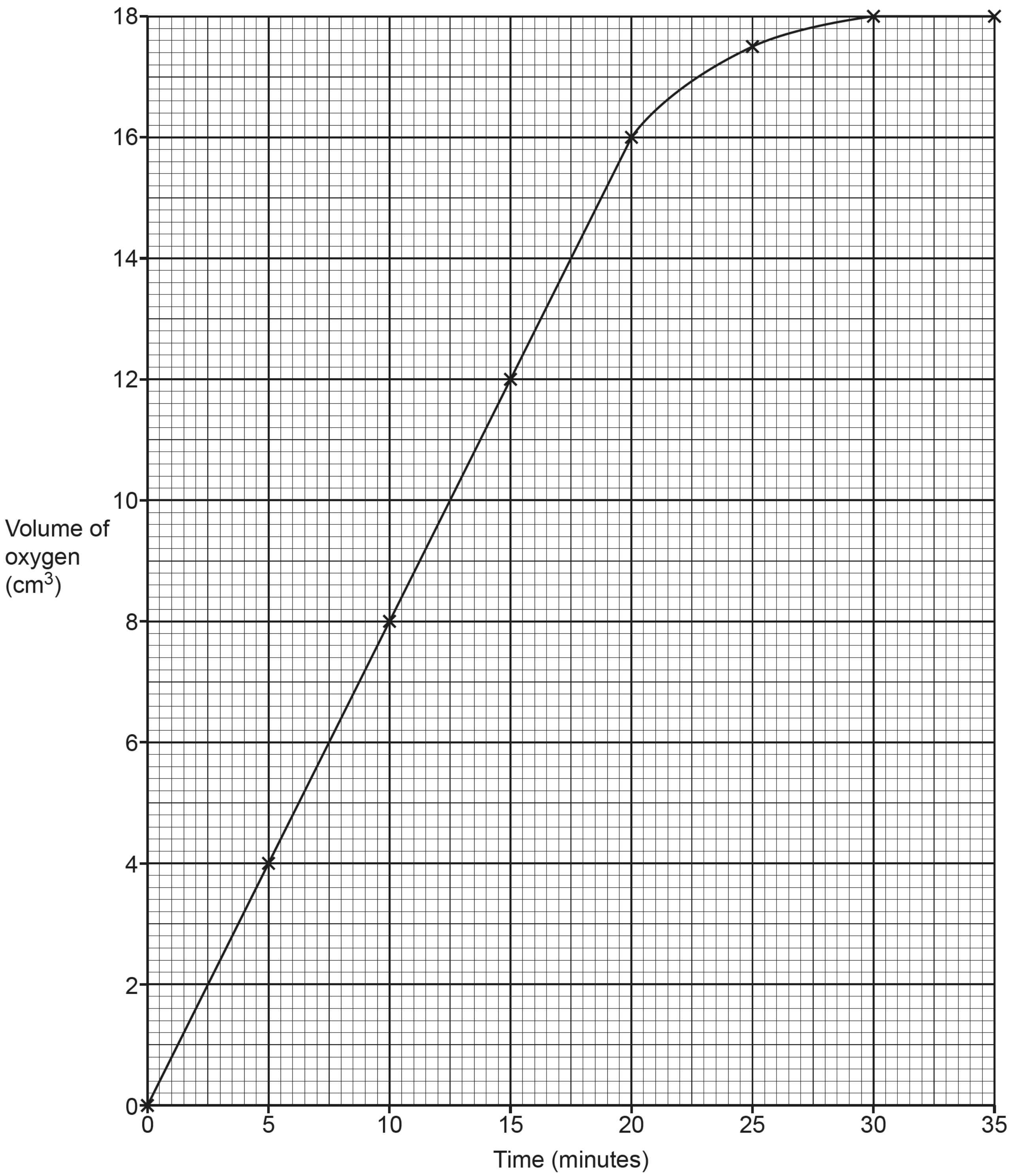
The table shows the student's results.

	Volume of oxygen (cm^3)	
Time (minutes)	Catalyst **A**	Catalyst **B**
0	0.0	0.0
5	4.0	5.0
10	8.0	10.0
15	12.0	15.0
20	16.0	16.5
25	17.5	18.0
30	18.0	18.0
35	18.0	18.0

The results for catalyst **A** are shown on **Fig. 16.1**.

Plot the results for catalyst **B** on **Fig. 16.1** and draw a line of best fit. **[2]**

Fig. 16.1



Most candidates correctly plotted the results for catalyst B, but many did not recognise that point (20, 16.5) was an anomalous result and hence did not gain the line of best fit mark. Some candidates interpreted the line of best fit as a straight line.

Question 16 (c)

(c) The student thinks catalyst **B** is the better catalyst.

Explain why the student is correct. Use data from the graph.

....

....

.... **[2]**

Answers to this question were detailed showing that candidates had a good understanding of how the graph linked to rate of reaction. The most successful candidates selected data from the graph and used this to support their answer, as well as writing about the line for catalyst B being steeper, indicating that the reaction with catalyst B is faster.

Question 16 (d)

(d) The volume of oxygen made in each experiment is 18 cm^3.

Explain why it is the same value.

....

.... **[1]**

Good responses to this question identified that the same volume of hydrogen peroxide was used in each experiment or wrote about the fact that catalysts only affect the rate of reaction and not the yield of product. Candidates who did not gain the mark often wrote about the idea of a limiting reactant, not recognising that there is only one reactant in this reaction.

Question 16 (e)

(e) The student repeats the experiment with **1.0 g** of catalyst **A** instead of 0.5 g.

What is the volume of oxygen gas made at the end of the experiment?

Volume of oxygen gas = ... cm^3 **[1]**

Misconception

? 36 cm^3 was a common misconception in this question, with candidates thinking that doubling the mass of the catalyst would double the volume of oxygen gas made.

Question 16 (f)

(f) The student thinks the decomposition of hydrogen peroxide will be faster at 30 °C than at room temperature.

Describe an experiment the student could do, and its results, to show the reaction is faster at 30 °C.

....

....

....

....

.... **[3]**

While many candidates described carrying out the experiment at 30°C in a water bath, they often did not describe the details of the measurements they would take, so only gained 1 mark. More successful candidates gave good descriptions of how the volume of gas could be measured, using a gas syringe, at specific time intervals and went on to explain that they would need to compare the results to those at room temperature and/or identify that the gas would be made quicker at 30°C.

Lower attaining candidates tended to give vague answers such as carrying out the experiment at different temperatures or repeating the experiment at 30°C, without clearly explaining what they were measuring.

Exemplar 1

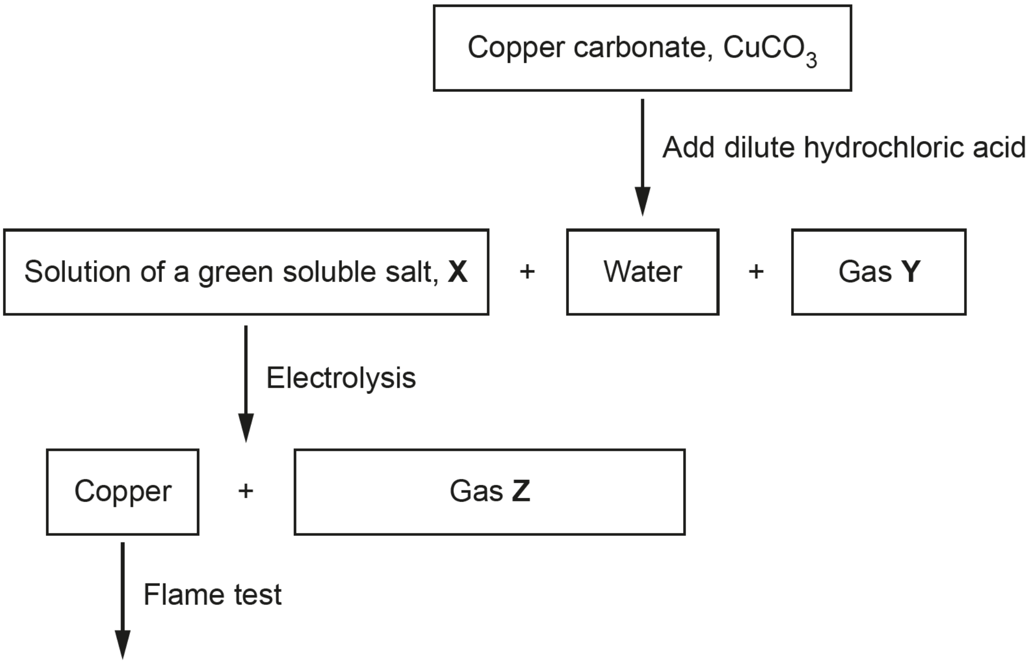
The student could also carry out the decomposition experiment in a water bath set to 30°C, using the two catalysts one at a time. She could then measure the volume of oxygen produced (using a gas syringe) every five minutes and plot her results on the previous graph. At 30°C, the rate of decomposition will be faster, and the gradients of the lines will be steeper. **[3]**

This response was given 3 marks. The candidate has described the experiment that the student should do and there is a clear statement of how the results will show that the reaction is faster at 30°C.

Question 17 (a)

17 A teacher investigates the reactions of copper carbonate, $CuCO_3$.

The diagram shows the reactions the teacher does.



(a) State the name of the soluble salt, **X**.

.... **[1]**

Most candidates correctly identified the soluble salt as copper chloride. The most common incorrect answers were copper, copper sulfate and copper hydroxide.

Question 17 (b)

(b) State the name of gas **Y**.

.... **[1]**

Most candidates correctly identified gas Y as carbon dioxide.

Question 17 (c)

(c) Gas **Z** turns damp blue litmus paper white.

State the name of gas **Z**.

.... **[1]**

Most candidates recalled the test for chlorine gas. A common error was candidates writing chloride.

Question 17 (d)

(d) The teacher performs a flame test of the copper made by the electrolysis of **X**.

What colour flame does the teacher observe?

.... **[1]**

Most candidates knew that copper gives a green-blue / green / blue flame.

Question 17 (e)

(e) Copper metal is extracted from copper oxide by heating with carbon as shown in the equation.

copper oxide + carbon $\rightarrow$ copper + carbon dioxide

Explain why copper is extracted.

Use ideas about the reactivity series.

....

.... **[1]**

The idea that carbon is more reactive than copper (or vice versa) was well known by candidates and examiners saw many well written answers describing the displacement of copper by carbon or the reduction of copper oxide by carbon.

Question 17 (f)

(f) Copper is used to make useful alloys.

The table gives information about some copper alloys.

Alloy	**Main metals**	**Uses**
duralumin	copper and	aircraft parts
brass	copper and	musical instruments
bronze	copper and tin	....

Complete the table. **[2]**

Most candidates recalled that duralumin contained aluminium, but less were able to recall zinc in brass. Iron was the most common incorrect answer for brass. Examiners accepted a wide range of uses for bronze, with coins and medals the most frequently seen answers.

Question 18 (a)

18 The table shows information about some compounds of carbon.

Compound	**Formula**
A	C_2H_4
B	C_2H_5OH
C	C_3H_7COOH
D	C_4H_{10}
E	C_6H_{14}

(a) Compounds **D** and **E** belong to the homologous series called the **alkanes**.

What is the **general formula** of the alkanes?

.... **[1]**

Misconception

? $C_n + H_{2n+2}$ was a common misconception, with an incorrect + implying two compounds.

Question 18 (b)

(b) Which homologous series does compound **C** belong to?

Tick (✓) the correct answer.

Alcohols ☐

Alkenes ☐

Carboxylic acids ☐

Esters ☐

[1]

Most candidates recognised that compound C was a carboxylic acid.

Misconception

Alcohol was the most common misconception.

Question 18 (c)

(c) Compound **A**, C_2H_4, burns in oxygen.

Write the **balanced symbol** equation for the **incomplete** combustion of compound **A**.

.... **[2]**

Less successful candidates wrote an equation for complete, rather than incomplete, combustion. Hydrogen and methane were also often seen as incorrect products.

Question 18 (d)

(d) Compound **D** and compound **E** are obtained from crude oil by fractional distillation.

Explain how fractional distillation separates compound **D** and compound **E**.
Use ideas about intermolecular forces.

....

....

....

.... **[3]**

Good responses to this question made the link that larger molecules have stronger intermolecular forces and hence higher boiling points.

Less successful candidates tended to ignore the hint in the question to use ideas about intermolecular forces and wrote instead about the process of fractional distillation in terms of the fractionating column, temperature gradient and alkanes condensing at different levels with no reference to intermolecular forces of molecular size. Some described that compound E had a higher boiling point, but then did not explain why.

Question 18 (e)

(e) Crude oil is being formed extremely slowly.

What term describes resources, like crude oil, that are being formed extremely slowly?

.... **[1]**

Misconception

The term finite was only known by the highest attaining candidates, with non-renewable being the most common misconception. Fossil fuel was also a common incorrect response.

Question 18 (f)

(f) Petrol is a mixture of hydrocarbons obtained from crude oil.

When petrol burns in a car engine the exhaust gases contain nitrogen monoxide, NO, and carbon monoxide, CO.
These are atmospheric pollutants.

Describe one environmental problem for each gas.

NO ....

CO ....
[2]

Lower attaining candidates attributed global warming / greenhouse effect to both NO and CO. Vague answers such as 'causes pollution' and 'harmful to plants / animals' were also common. The toxic nature of CO was better known than the link between NO and acid rain.

Question 18 (g) (i)

(g) Most cars have catalytic converters which catalyse the reaction between nitrogen monoxide and carbon monoxide to make nitrogen and carbon dioxide gases.

(i) Explain how the use of a catalyst in the catalytic converter increases this rate of reaction.

....

....

.... **[2]**

Many candidates gave a correct statement about what is meant by a catalyst in terms of a substance that speeds up a reaction (given in the stem of the question) but is not used up. The command word 'explain' required candidates to describe how catalysts speed up a reaction in terms of providing an alternative reaction pathway with a lower activation energy.

Question 18 (g) (ii)

(ii) The equation shows the reaction that takes place in a catalytic converter.

$2CO + 2NO \rightarrow N_2 + 2CO_2$

During a car journey, 187 g of carbon dioxide is made by the catalytic converter.

Calculate the **volume of carbon monoxide**, in dm^3, removed from the exhaust gases.

Relative atomic mass (A_r): C = 12.0 O = 16.0

Volume of carbon monoxide = ... dm^3 **[4]**

This question proved to be a real discriminator, as did all the calculations on this paper. Only the highest attaining candidates worked this through to the correct answer. If candidates did not obtain an answer of 102 dm^3 examiners looked to award marks for working out and/or error carried forward. It is worth centres stressing to candidates that this is only possible when working for the answer is clearly set out.

Misconception

Common errors / misconceptions in this calculation included

- calculating the moles of CO_2 using the M_r as 88 rather than 44, giving the number of moles as 2.125
- not making the link that moles of CO_2 = moles of CO, so losing the opportunity to pick up an error carried forward mark
- not recalling the formula 'vol = mol x 24', with many candidates multiplying 4.25 (or 2.125) mol of CO by 28 (or 56) to give a mass of CO, rather than the required volume of CO.

Question 19 (a)

19 A student neutralises dilute sulfuric acid, H_2SO_4, with ammonia, NH_3, to make ammonium sulfate, $(NH_4)_2SO_4$.

This is the equation for the reaction.

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

(a) The student makes 4.22 g of ammonium sulfate. The percentage yield is 80%.

Calculate the **mass of sulfuric acid** the student used in the reaction.

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

Relative atomic mass (A_r): H = 1.0 N = 14.0 O = 16.0 S = 32.1

Mass of sulfuric acid = ... g **[5]**

Good responses to this question calculated the theoretical yield of ammonium sulfate as 5.275g, and hence the mass of sulfuric acid used as 3.92g.

A significant number of candidates correctly worked out the theoretical yield but then continued their calculation using 4.22g as the theoretical yield.

Many candidates scored 2 marks, usually for the 2 correct M_r values and an answer to 3 significant figures.

Assessment for learning

Appendix 5e of the specification lists the mathematical skills that will be assessed within the context of relevant chemistry. Skill M2a requires candidates to use an appropriate number of significant figures. Incorrect rounding to 3 significant figures, giving 3.917, was a common error.

Question 19 (b)

(b) The table gives some information about the two methods of producing ammonium sulfate.

Laboratory	Industry
titration of dilute sulfuric acid and ammonia solution	uses raw materials to make sulfuric acid and ammonia in several stages
batch process	continuous process
small scale	large scale
slow process	quick process
atom economy is 100%	atom economy is 100%
	ammonium sulfate can be made from by-products of other processes

Evaluate the information to suggest which method is more suited to making large amounts of chemicals such as fertilisers.

....

....

....

....

....

.... **[3]**

This question was extremely well answered with the vast majority of candidates successfully evaluating the data to suggest why the industry process is more suited to making fertilisers. They often linked the marking points to profitability, showing an awareness of why industry uses up-scales during manufacturing.

Question 19 (c)

(c) Ammonium sulfate, $(NH_4)_2SO_4$, is used as a fertiliser because it contains nitrogen.

State why nitrogen is one of the essential elements needed by plants.

.... **[1]**

Many candidates wrote that plants require nitrogen for growth, which was insufficient to gain the mark.

Question 20*

20* Magnesium sulfate, $MgSO_4$, is made by a neutralisation reaction.

Methods 1 and **2** show two different ways of making magnesium sulfate.

Method 1 – Reaction of sulfuric acid with magnesium carbonate.
$H_2SO_4 + MgCO_3 \rightarrow MgSO_4 + H_2O + CO_2$

Method 2 – Reaction of sulfuric acid with magnesium oxide.
$H_2SO_4 + MgO \rightarrow MgSO_4 + H_2O$

A company wants to make magnesium sulfate as sustainably as possible.

Use the idea of **atom economy** to help explain which method, **1** or **2**, the company should use to make magnesium sulfate.

Relative atomic mass (A_r): C = 12.0 H = 1.0 Mg = 24.3 O = 16.0 S = 32.1

....

....

....

....

....

.... **[6]**

This 6-mark, Level of Response, question assessed AO2 and AO3. At Level 3 (5 - 6 marks) candidates needed to calculate the atom economy for both methods 1 and 2, and then explain why the company should use method 2.

Some of the responses were excellent, showing a clear understanding of atom economy calculations and the importance of sustainability and environmental impact of reaction by-products.

The answers of less successful candidates often

- referenced the formation of carbon dioxide in method 1 but then didn't make the link to it being a greenhouse gas / cause of global warming, instead just stating it was a waste product or a pollutant
- stated that the atom economy for both methods is 100%, having calculated the sum of the relative formula masses of the reactants and compared with the sum of the relative formula masses of the products.

Exemplar 2

Atom economy of method 1 = $\frac{(24.3 + 32.1 + 16 + 16 + 16 + 16)}{(120.4 + 2 + 16 + 12 + 32)} = \frac{120.4}{182.4} \times 100$
$= 66\%$

Atom economy method 2 = $\frac{120.4}{138.4} \times 100 = 86.994 = 87\%$

They should use method 2 because not only does it have a higher atom economy which means they don't waste as much money on raw materials etc for unuseful by-products, the only waste product is water which could be reused – for example it could be used to make potable water. Not only that, Method 1 is less sustainable not only because of its lower atom economy, but because one of its by-products is CO_2 & this either needs to have extra money spent to dispose of it properly, or it will be released into the atmosphere, further contributing to the enhanced greenhouse effect. **[6]**

This is a Level 3 (6 mark) response. The candidate has correctly calculated the atom economy for both method 1 and 2, showing their working out clearly. There is then a clear explanation of why the company should use method 2 to make magnesium sulfate in terms of both sustainability and the potential environmental impact of the CO_2 produced in method 1.

Question 21 (a)

21 Hydrogen gas is made by the reaction between methane, CH_4, and steam.

The reaction reaches a **dynamic equilibrium**.

This is the equation for the reaction.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

(a) State what is meant by a **dynamic equilibrium**.

....

....

....

.... **[2]**

Good responses to this question described that the forward reaction was happening at the same rate as the backward reaction, and the concentrations of the reactants and products do not change. The answers of less successful candidates demonstrated a lack of understanding of the concept of equilibrium by referring to the same amount of reactants and products being made. Alternatively, they referred to the reaction being reversible and happening in a closed system.

Question 21 (b) (i)

(b) The position of equilibrium moves if the reaction conditions are changed.

(i) The forward reaction is **endothermic**.

The **temperature** of the equilibrium mixture is **increased**.

State and explain what happens to the position of the equilibrium.

....

....

.... **[2]**

Misconception

? A common misconception was that an increase in temperature would favour the backward, exothermic, reaction.

Question 21 (b) (ii)

(ii) The highest yield of hydrogen gas is made using a low pressure, such as 1 atmosphere.

The reaction is actually carried out using a catalyst at a pressure of 30 atmospheres.

Suggest why a pressure of 30 atmospheres is used.

....

.... **[1]**

Lower attaining candidates often thought that 30 atmospheres pressure is easier to achieve or safer than 1 atmosphere pressure. More successful candidates appreciated that 30 atmospheres is a compromise pressure between yield and rate.

Question 21 (c)

(c) A factory uses 200 tonnes of methane a day.

The factory produces 68.4 tonnes of hydrogen per day as shown in the equation.

$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$

Calculate the **percentage yield of hydrogen**, $\mathbf{H_2}$.

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

Relative atomic mass (A_r): H = 1.0 C = 12.0

Percentage yield of hydrogen = ... % **[4]**

Only the higher attaining candidates were able to calculate the theoretical yield of hydrogen as 75 tonnes, and then to go on to calculate the percentage yield as 91%.

Misconception

Common errors / misconceptions in this calculation included

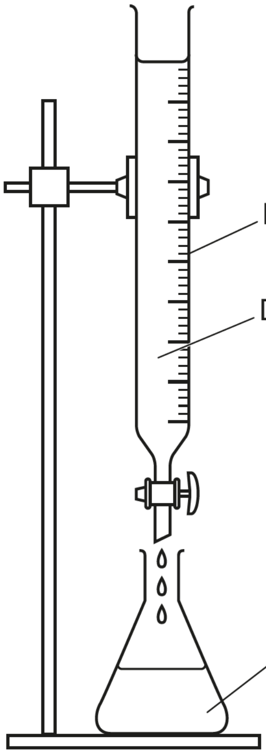
- correctly calculating the moles of H_2 as 37.5, but then multiplying that by 6 (rather than 3) to calculate the mass of H_2 as 225 tonnes.
- using the data in the question to calculate the % yield, i.e. 68.4 / 200 x 100 = 34.2%.

Question 22 (a) (i)

22 A student does a titration with an acid and an alkali.

The student uses dilute hydrochloric acid, sodium carbonate solution and an indicator solution.

The diagram shows the apparatus they use.



The student uses:

- 25.0 cm^3 of sodium carbonate solution in the conical flask
- dilute hydrochloric acid of concentration 0.12 mol / dm^3 in the burette.

The student repeats the titration 4 times.

The table shows the student's results.

Titration number	**1**	**2**	**3**	**4**
Final burette reading (cm^3)	20.25	20.51	37.60	39.15
Initial burette reading (cm^3)	0.00	0.00	16.10	18.74
Volume of acid used (cm^3)	20.25	20.51	....	20.41

(a) **(i)** Calculate the volume of acid used in titration number **3**.

Write your answer in the table. **[1]**

The volume of acid was correctly calculated by virtually all candidates.

Question 22 (a) (ii)

(ii) The student uses methyl orange as the indicator in the experiment.

Explain why the student does **not** use universal indicator.

....

.... **[1]**

Good responses to this question described that methyl orange gives a sudden colour change, whereas universal indicator gives a range of colours.

Question 22 (a) (iii)

(iii) The student decides to only use the results from titration numbers **2** and **4**.

Explain why.

....

.... **[1]**

Many candidates appreciated that the results in titrations 2 and 4 are concordant.

Question 22 (a) (iv)

(iv) The equation for the reaction between dilute hydrochloric acid and sodium carbonate solution is shown.

$$2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2$$

Calculate the concentration of the sodium carbonate solution in mol/dm^3.

Use the average volume of acid used in titration numbers **2** and **4**.

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

Concentration of the sodium carbonate solution = ... mol/dm^3 **[5]**

Higher attaining candidates were able to calculate the concentration of sodium carbonate solution. Less successful candidates usually scored 2 marks for the average titre and an answer to a calculation given to 2 significant figures.

Misconception

Common errors / misconceptions in this calculation included

- ignoring the stoichiometry of the reaction and not recognising that the mole ratio was 2:1
- using the average titre of the acid, rather than the volume of alkali, to calculate the concentration of the alkali.

Assessment for learning

Many candidates still forget to convert cm^3 to dm^3 before calculating moles or concentrations.

Exemplar 3

mean volume of acid $= \frac{20.51 + 20.41}{2} = 20.46\ cm^3$

$20.46\ cm^3 = 0.02046\ dm^3$

concentration of acid = $0.12\ mol/dm^3$

$c = \frac{m}{v}$ $\quad 0.12 \times 0.02046 = 2.4552 \times 10^{-3}$ moles

$m = c \times v$

mole ratio 2 : 1

$2.4552 \times 10^{-3} \div 2 = 1.2276 \times 10^{-3}$ moles Na_2CO_3

volume $= 25\ cm^3 = 0.025\ dm^3$

concentration $= \frac{moles}{volume} = \frac{1.2276 \times 10^{-3}}{0.025} = 0.049104$

$= 0.049$

This response gained full marks for this titration calculation. The candidate has clearly set out their working out, making it easy for the examiner to follow. The candidate has calculated the average titre and then shown the use of 'm = c x v' to work out the moles of acid. They have appreciated the mole ratio and correctly calculated the moles of alkali, going on to use this to calculate the concentration of the alkali. The candidate had correctly given their response to 2 significant figures.

Question 22 (b) (i)

(b) Sodium chloride, Na*Cl*, is made in the student's titration.

Sodium chloride contains the cation Na^+ and the anion Cl^-.

Describe the tests, and their positive results, that the student can do to prove that sodium chloride is made in the reaction.

(i) Cation Na^+

Test ....

....

Result ....

....

[2]

The use of a flame test, and its positive result, was well known.

Question 22 (b) (ii)

(ii) Anion Cl^-

Test ....

....

Result ....

.... **[2]**

The use of silver nitrate to give a white precipitate was well known.

Misconception

Common errors / misconceptions in b(i) and (ii) were the use of electrolysis or litmus paper to identify the cation / anion. In part (ii) some candidates gave the test for chlorine, rather than chloride ions.

Question 23 (a)

23 A car manufacturer is concerned about the carbon dioxide, CO_2, emissions of different cars during their lifetime.

The car manufacturer does a life-cycle assessment for three types of car they are developing:

- a petrol car
- a diesel car
- an electric car.

The car manufacturer also looks at refuelling the electric car using electricity generated by 'renewable electricity' and '100% coal electricity'.

(a) Why does the car manufacturer do a life-cycle assessment?

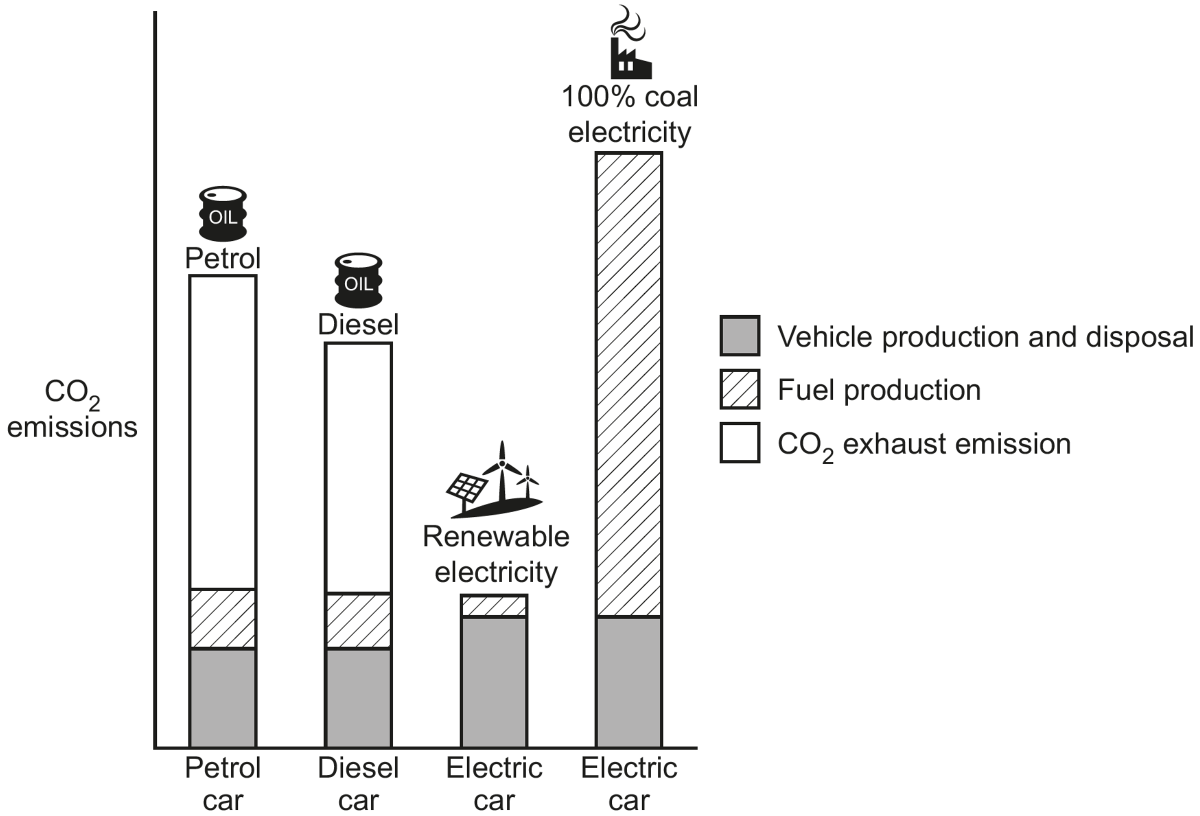
....

.... **[1]**

Good responses to this question described working out the potential environmental impact at each stage of the life of a car. Lower attaining candidates often just referred to manufacturing or running the car or talked about sustainability.

Question 23 (b) (i)

(b) The graph shows the life-cycle assessment for the three types of car.



(i) Estimate the percentage of CO_2 emissions for a **diesel car** which come from **fuel production**.

Percentage of CO_2 emissions = ... % **[1]**

Less successful candidates appeared to just guess the answer to this question rather than taking measurements from the graph.

Question 23 (b) (ii)

(ii) The CO_2 emissions for an electric car are much greater when the car is refuelled using electricity generated by burning coal, rather than renewable electricity.

Suggest why.

....

....

.... **[2]**

More successful candidates appreciated that coal is a fossil fuel, although very few stated it is a hydrocarbon. Many candidates realised that burning coal produces carbon dioxide.

Question 23 (c)

(c) Petrol and diesel are both obtained from crude oil.

Petrol molecules are smaller than diesel molecules.

Petrol has a **lower boiling point** than diesel. Explain why.

....

.... **[1]**

Many candidates were able to explain that petrol has weaker intermolecular forces than diesel. Less successful candidates stated that petrol has less or weaker <u>bonds</u> to break.

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