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OCR
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GCSE (9–1)

Examiners' report

GATEWAY SCIENCE CHEMISTRY A

J248

For first teaching in 2016

J248/04 Summer 2023 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. A selection of candidate answers is 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.

Paper 4 series overview

J248/04 is the second of two examination components for candidates entered for the higher tier of GCSE 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.

The Level of Response question assesses the quality of communication as well as knowledge and understanding. Throughout the paper there are some questions that are designed to assess candidates' knowledge and understanding of practical skills used in the specification. These questions demand responses that identify a candidate's awareness of the skills required to successfully complete practical activities and investigations.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• performed standard calculations following the required rubric (e.g. clear working, components and, where needed, significant figures) relating to mass/concentration: Question 16 (d), molar gas volume: Question 18 (d), % yield: Question 21 (c) and titrations: Question 23 (b) (ii) • produced a clear, concise and well-structured answer for the Level of Response question: Question 19 • understood practical techniques: Questions 16 (a) and (b), 22 (a) and 23 (a) and (b) • applied knowledge and understanding to questions set in a novel context • explained observations using scientific ideas: Questions 20 (c) (ii), 21 (a) (i), 22 (c).	• 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. Questions 17 (a), 18 (b), 20 (b), 20 (e) • showed imprecise use of scientific terminology, e.g. Questions 20 (c) (ii), 21 (a) (i) and (ii), 22 (c) and 22 (e) • 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 • found questions designed to assess candidates' practical abilities challenging and indicated a lack of awareness of the skills involved in practical activities and investigations.

Section A overview

Candidates were able to successfully demonstrate their knowledge and understanding on these questions, with all the multiple-choice questions in Section A being attempted by all candidates. Mistakes most commonly occurred on Questions 1, 4, 8 and 15.

Question 1

1 Crude oil is a resource that is being made extremely slowly.

Which word describes a resource that is being made extremely slowly?

A Finite

B Hydrocarbon

C Non-renewable

D Petrochemical

Your answer ☐ **[1]**

Misconception

? A common error was C, with candidates not appreciating the difference between finite (a resource that is being made extremely slowly) and non-renewable (a resource that is being used faster than it can be replaced).

Question 4

4 Which gas was the most abundant in the Earth's early atmosphere?

A Argon

B Carbon dioxide

C Nitrogen

D Oxygen

Your answer ☐ **[1]**

A large majority of candidates correctly answered this question. C, nitrogen was a common incorrect response, possibly because nitrogen is the most abundant gas in the Earth's present day atmosphere.

Question 8

8 Why are alloys stronger than the pure metals which they are made from?

A Alloys combine the properties of the metals they are made from.

B Alloys contain atoms of different sizes.

C Alloys contain different atoms bonded together.

D Alloys have strong bonds between their molecules.

Your answer ☐ **[1]**

A common error was A, with candidates thinking that alloys combine the properties of the metals they are made from.

Question 15

15 What is the half equation for the reaction at the **anode** in a hydrogen/oxygen fuel cell?

A $2H_2 + O_2 \rightarrow 2H_2O$

B $2H_2 \rightarrow 4H^+ + 4e^-$

C $4H^+ + 4e^- \rightarrow 2H_2$

D $4H^+ + O_2 + 4e^- \rightarrow 2H_2O$

Your answer ☐ **[1]**

C and D were common incorrect responses, with candidates focusing on reactions of H+ ions, rather than the loss of electrons by hydrogen molecules at the anode to become hydrogen ions.

Section B

Question 16 (a) (i)

16 A student investigates two solutions, **A** and **B**.

They know that
- one solution contains a halide ion
- the other solution contains a different anion.

They test 2 cm^3 of each solution for the halide ion using this method:

- Add a few drops of dilute hydrochloric acid and shake.
- Add a few drops of silver nitrate solution.
- Record the colour of the precipitate.

(a) The teacher says that the student should have used a different acid instead of dilute hydrochloric acid.

(i) State the name of the acid the student should have used.

.... **[1]**

Many candidates correctly stated nitric acid, although sulfuric acid was a common error. Some candidates stated chemicals which were not acids.

Question 16 (a) (ii)

(ii) Explain why using dilute hydrochloric acid would affect the results of this test.

....

....

.... **[2]**

Many candidates did not appreciate that hydrochloric acid contains chloride ions, which would form a white precipitate. Of those candidates who did gain the first mark for the idea of adding chloride ions, many didn't gain the second mark because they did not clearly state the consequence of this. Lower attaining candidates often attributed the unsuitability of hydrochloric acid to the fact that it was dilute.

Question 16 (b)

(b) The student repeats the test for halide ions using the correct acid and silver nitrate solution.

They also test each solution using a few drops of dilute hydrochloric acid followed by a few drops of barium chloride solution.

The table shows their results.

Solution	Observation with silver nitrate solution	Observation with barium chloride solution
A	cream precipitate	no change
B	no change	white precipitate

State the name of the anion in each solution.

Solution **A** ....

Solution **B** .... **[2]**

Just under half of candidates gained 1 or 2 marks here. Sulfate ions in solution B was correct more often than bromide ions in solution A. A common error was bromine rather than bromide.

Question 16 (c)

(c) Solution **A** also contains copper ions, Cu^{2+}.

Copper ions react with hydroxide ions, OH^-, to make a precipitate of copper(II) hydroxide.

Write the **balanced ionic** equation for this reaction. Include the state symbols.

.... **[3]**

Lower attaining candidates were unable to deduce the formula for copper(II) hydroxide with CuOH and $CuOH_2$ common errors. The state symbol for Cu^{2+} was often given as (s) and $Cu(OH)_2$ was often given as (aq).

Question 16 (d)

(d) Barium chloride solid is toxic if swallowed and harmful if inhaled.

Barium chloride solutions with concentrations of 21 g / dm^3 are suitable for experiments in school.

Calculate the mass of barium chloride that should be dissolved in 25 cm^3 of water to make a solution with a concentration of 21 g / dm^3.

Use the equation:

$$\text{concentration} = \frac{\text{mass}}{\text{volume}}$$

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

Mass of barium chloride = ... g **[3]**

Many candidates gained full marks for this question. Common errors were not converting cm^3 to dm^3, or not giving the answer to 2 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 2 significant figures, giving 0.525g, was a common error.

OCR support

Our mathematical skills handbook and mathematical skills check-in resources might be useful to use with students as they start studying GCSE chemistry to assess skills and throughout to reinforce learning.

Question 17 (a)

17 The table shows information about three different polymers, **A**, **B** and **C**.

Tensile strength is the amount of load a material can take before it breaks.

	Melting point (°C)	**Softening temperature (°C)**	**Stiffness (MPa)**	**Tensile strength (MPa)**
A	130	72	980	15
B	240	95	3200	65
C	250	75	2400	50

(a) A company wants to use a polymer to make a disposable cup for hot drinks.

Suggest and explain which polymer, **A**, **B or C**, the company should use.

Polymer ....

Reason ....

....

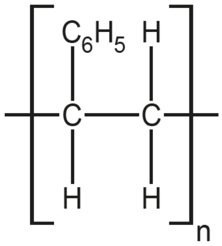
....

.... **[3]**

A large majority of candidates were able to gain some marks from this question. Responses from high attaining candidates to this question suggested the use of polymer B and then used the data in the table to explain their choice, e.g. B will not melt because its melting point is above that of a hot drink. Lower attaining candidates tended to just state facts from the table without qualifying their answer.

Question 17 (b)

(b) This is the repeating unit in polymer **B**.



Draw the structure of the **monomer** from which polymer **B** is made.

[2]

Many candidates were able to draw the structure of the monomer. The most common error was not reinstating the double bond between the carbon atoms.

Question 17 (c)

(c) Some substances are naturally occurring polymers.

Draw lines to connect each **monomer** with its naturally occurring **polymer**.

Monomer	**Polymer**
amino acids	DNA
nucleotides	proteins
sugars	starch

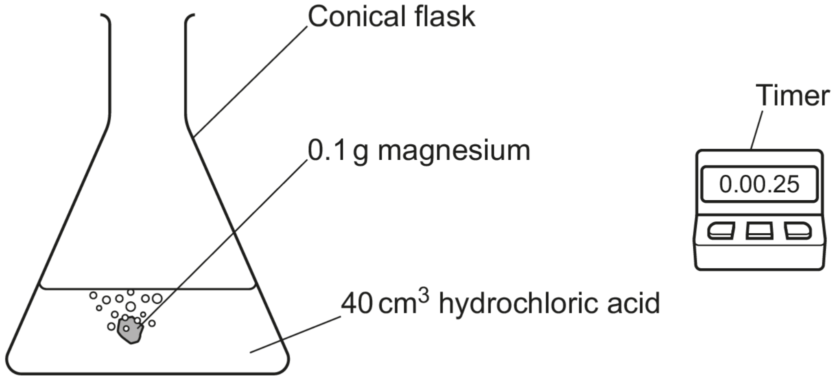
[2]

Most candidates scored 2 marks for this question.

Question 18 (a)

18 A teacher investigates the reaction between hydrochloric acid and magnesium.

The diagram shows the teacher's experiment.



The teacher uses five different concentrations of hydrochloric acid. Each time they react the hydrochloric acid with 0.1 g of magnesium powder.

The table shows the teacher's results.

Concentration of hydrochloric acid (mol/dm^3)	**Time for magnesium powder to react (s)**
0.5	117
1.0	82
1.5	48
2.0	24
2.5	16

(a) Write the **balanced symbol** equation for the reaction between hydrochloric acid, HCl, and magnesium.

.... **[2]**

Most candidates were able to write the correct balanced symbol equation for the reaction between hydrochloric acid and magnesium. 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, $2HCL + Mg \rightarrow MgCl2 + H_2$, would gain 1 mark. When candidates did not gain marks, it was often because they wrote the formula for magnesium chloride as $MgCl$.

Question 18 (b)

(b) The teacher says, 'The reaction is faster the more concentrated the hydrochloric acid'.

Use the results to explain why the teacher is **correct**.

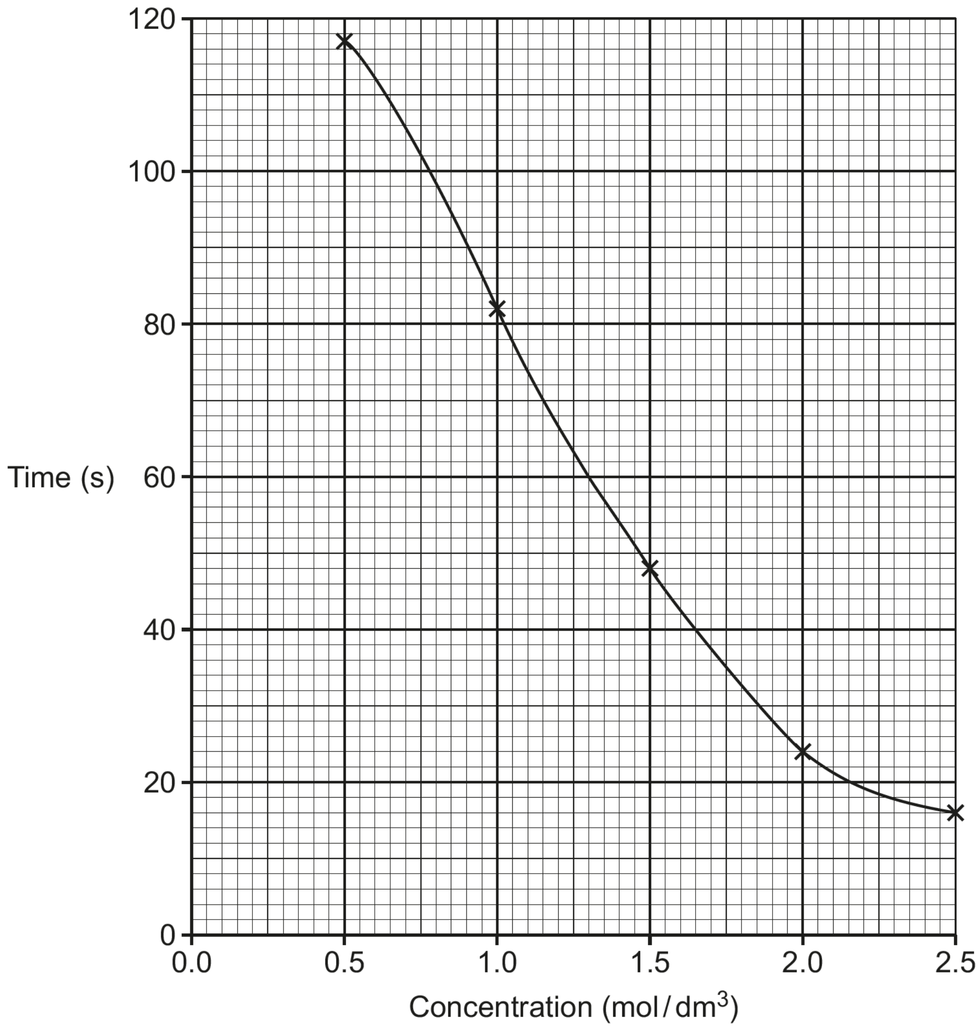
....

.... **[1]**

Most candidates explained that the reaction at higher concentration took less time. Lower attaining candidates simply quoted experimental results rather than drawing a conclusion from the data, or explained why the reaction would be faster using particle theory rather than using the results.

Question 18 (c) (i)

(c) The graph shows the teacher's results.



(i) Use the graph to deduce the time for magnesium powder to react if 1.3 mol / dm^3 hydrochloric acid is used.

Time = ... s **[1]**

Most candidates correctly used the graph to deduce the time to be 60s.

Question 18 (c) (ii)

(ii) The teacher repeats the experiment with 0.1 g of magnesium **ribbon**.

Draw a line on the graph to show the results you would expect the teacher to get. **[2]**

Successful responses to this question drew a line above the line for magnesium powder but following the general shape.

Assessment for learning

Some candidates omitted this question. Centres are encouraged to make candidates aware that not all questions have a dotted answer line, e.g. graph questions or table completion.

Question 18 (d)

(d) The teacher used 0.1 g of magnesium.

0.1 g of magnesium reacts with hydrochloric acid to make 0.008 g of hydrogen gas.

Calculate the volume occupied by 0.008 g of hydrogen gas **in cm^3**.

Relative atomic mass (A_r): H = 1.0

Volume of hydrogen gas = ... cm^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 96 cm^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 a response is clearly set out.

Misconception

Common errors/misconceptions in the calculation included:

- taking the M_r of H_2 to be 1
- not converting dm^3 to cm^3
- not recalling the formula 'volume = mol x 24', with many candidates giving a mass of H_2 rather than the required volume.

Assessment for learning

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

Question 19*

19* A life-cycle assessment looks at the potential environmental impact at each stage of the life of a product.

A car manufacturer does a life-cycle assessment for cars made from

- steel
- aluminium.

The table gives information about the life-cycle impact of cars made from steel and aluminium.

	Steel	**Aluminium**
Production CO_2 emissions from mining the ore, extracting the metal, to manufacturing the car	6444 kg	9794 kg
Driving CO_2 emissions from the use of petrol or diesel	37 054 kg	36 248 kg
End of life CO_2 emissions saved by recycling metals rather than extracting new metals	 –1546 kg	 –3634 kg

Evaluate which type of metal has the smallest environmental impact over its lifetime.
Use the information in the table, and your own knowledge of how metals are extracted.

....

....

....

....

....

.... **[6]**

This 6-mark Level of Response question assessed AO2 and AO3. At Level 3 (5 - 6 marks) candidates needed to analyse the information to give a clear and detailed comparison of the environmental impacts of each car and then to use their knowledge and understanding of scientific ideas to explain why a steel car has the smallest environmental impact.

Some of the responses were excellent, showing a clear numerical analysis of the data at each stage of the life-cycle assessment and explaining the extraction of aluminium by electrolysis compared to the extraction of iron by reduction of iron ore with carbon.

The responses of lower scoring candidates often:

- simply quoted data from the table rather than analysing and evaluating the data
- did not apply any knowledge of how metals are extracted.

Exemplar 1

~~Making aluminium Aluminium car~~ • The production of aluminium emits 9794kg of CO_2 whereas the production of steel emits 6444kg of CO_2 so ~~aluminium~~ production of aluminium emits 3350kg more CO_2 into the environment therefore the production of aluminium ~~is more~~ has a larger ~~impact~~ environmental impact than the production of steel.

• Driving a car made from steel emits ~~390~~ 37054kg but driving a car made from steel emits 36248kg of steel so driving a car made from steel emits 806kg more CO_2 than driving a car made from aluminium so driving a steel car has a larger environmental impact than driving an aluminium car.

• Recycling steel rather ~~ext~~ than extracting new steel saves 1546 kg of CO_2 emissions, ~~this is because~~ whereas recycling aluminium rather than extracting new aluminium saves 3639kg of CO_2 emissions so recycling aluminium saves 2088 kg ~~more~~ more CO_2 than recycling steel so ~~steel~~ recycling steel has a larger environmental impact than recycling aluminium. (additional space) [6]

The reason extracting aluminium ~~sold~~ releases significantly more CO_2 and ~~recycling~~ recycling aluminium saves significantly more CO_2 than steel is because aluminium is more reactive than carbon so it needs to be extracted by electrolysis which needs a lot of energy to power the electrical current and melt the ~~rock~~ electrolyte so ions can pass through. In the electrolysis process, at the cathode forms aluminium in a pure form and at the anode the oxygen from the original aluminium oxide reacts with the carbon ~~made~~ anode to form CO_2 which results in a significant amount of CO_2 being emitted and so a significant amount of CO_2 is saved when recycling aluminium since less electrolysis happens. However, steel contains iron which is less reactive than carbon so a displacement reaction which releases less energy and CO_2, can extract ~~steel~~ iron used to make steel: $2FeO + C \rightarrow 2Fe + CO_2$ – iron is oxidised. In conclusion although a significant amount of CO_2 is saved by recycling aluminium this does not compensate for the large amount of CO_2 emitted when aluminium is extracted so steel has the smaller environmental impact

This is a Level 3 (6 mark) response in which the candidate has quantitatively analysed the information to give a clear and detailed comparison of the environmental impacts of each car over its lifetime. The candidate has also applied their knowledge and understanding of scientific ideas to give a detailed evaluation of the difference in emissions and has correctly explained why the steel car has the smallest environmental impact.

Question 20 (a)

20 Butane, C_4H_{10}, is an alkane.

Butane undergoes complete combustion in oxygen.

(a) Write the **balanced symbol** equation for the complete combustion of butane.

.... **[2]**

Hydrogen, rather than water, was often seen as a product in this combustion reaction. Just over half of candidates gained some marks from this question.

Question 20 (b)

(b) **Table 20.1** lists the energy given out when 1 g of different alkanes burn.

Table 20.1

Alkane	Energy given out (kJ)
butane	49.2
ethane	52.6
methane	55.6
propane	50.4

State the relationship between the number of carbon atoms in the alkane and the energy given out.

....

.... **[1]**

A good majority of candidates gained 1 mark here. Lower attaining candidates stated that as the number of carbon atoms increased, the energy given out increased.

Question 20 (c) (i)

(c) Butane is found in the LPG fraction when crude oil is separated into different fractions by fractional distillation.

Table 20.2 shows some information about four other molecules that are found in four different fractions.

Table 20.2

Molecule	Formula	Boiling point (°C)
heptadecane	$C_{17}H_{36}$	302
eicosane	$C_{20}H_{42}$	342
tetracosane	$C_{24}H_{50}$	
octacosane	$C_{28}H_{58}$	436

(i) Predict the boiling point of tetracosane.

Boiling point of tetracosane = ... °C **[1]**

Most candidates correctly predicted the boiling point of tetracosane within the allowable range.

Question 20 (c) (ii)

(ii) Octacosane is separated lower down the fractionating column than the other three molecules in **Table 20.2**.

Explain why using ideas about intermolecular forces.

....

....

....

.... **[3]**

Successful responses to this question made the link that molecules separated lower down the fractionating column have stronger intermolecular forces, which require more energy to break, and hence have higher boiling points.

Less successful candidates tended to suggest that intermolecular forces between atoms were broken.

Exemplar 2

Octacosane is a larger hydrocarbon molecule so has stronger intermolecular forces which require more energy to overcome. As a result and as shown in the table it has a higher boiling point. This means it condenses near the bottom of the fractionating column where it is hotter because its boiling point is lower so it can turn into liquid form more easily than the other three **[3]**

This response identified that octacosane is a larger molecule and then made a clear link between molecular size, the strength of the intermolecular forces and the energy required to overcome the forces. The response scored all 3 marks in the first sentence, but also then correctly stated that octacosane has a higher boiling point and appreciated that the fractionating column is hotter at the bottom.

Question 20 (d)

(d) Cracking breaks down large molecules produced in fractional distillation into more useful molecules.

The equation shows the cracking of octacosane to make dodecane and **one** other product.

Complete and balance the equation.

$$\underset{\text{octacosane}}{C_{28}H_{58}} \longrightarrow \underset{\text{dodecane}}{C_{12}H_{26}} + \ldots\ldots\ldots\ldots\ldots$$

[2]

$C_{16}H_{32}$ was the most common correct response.

Question 20 (e)

(e) **Table 20.3** shows the percentage supply and demand for some of the different fractions obtained from crude oil.

Table 20.3

Fraction	Percentage supply (%)	Percentage demand (%)
LPG	2	4
petrol	5	23
naphtha	8	5
kerosene	12	7
diesel oil	17	23
fuel oil	56	38

More petrol can be obtained by cracking another fraction.

Suggest and explain which fraction is cracked to obtain petrol.

Fraction ....

Reason ....

.... **[2]**

Most candidates correctly suggested cracking fuel oil or kerosene as the supply of those fractions exceeds the demand. Less successful responses saw candidates choose diesel oil because the percentage demand is the same as petrol.

Question 21 (a) (i)

21 Methanol, CH_3OH, is made in industry by reacting carbon monoxide with hydrogen.

This is the equation for the reaction.

$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$

The forward reaction is exothermic.

(a) A temperature of 250 °C and a pressure of 100 atmospheres is used for the reaction.

(i) Describe and explain the effect on the yield of methanol from using a pressure of 15 atmospheres.

....

....

....

.... **[3]**

Many candidates were able to identify that the lower pressure would decrease the yield of methanol, explaining that the position of equilibrium would move to the left as there are more moles/molecules on the left-hand side of the equation. Lower attaining candidates usually explained the lower yield in terms of particle collisions and rate of reaction.

Question 21 (a) (ii)

(ii) The yield of methanol is greater when a temperature of 150 °C is used instead of 250 °C.

Suggest why a temperature of 150 °C is **not** used in industry.

....

.... **[1]**

Most candidates appreciated that the reaction would be slower at 150 °C. Two thirds of candidates were able to respond correctly to this question.

Question 21 (b)

(b) A catalyst is used to speed up the reaction.

Describe the effect on the position of equilibrium from using a catalyst.

....

.... **[1]**

Misconception

A common misconception was that using a catalyst would change the position of equilibrium.

Question 21 (c)

(c) A factory makes some methanol.

They predict they will make 60 tonnes of methanol. The reaction has a percentage yield of 78%.

Calculate the mass of methanol they actually make.

Mass of methanol = ... tonnes **[3]**

A very healthy proportion of candidates were given all 3 marks for correctly calculating the mass of methanol as 46.8 tonnes.

Question 21 (d) (i)

(d) **(i)** Draw the structural formula of methanol, CH_3OH.

[2]

The most common error in this question was the omission of the covalent bond between the O and the H atom. However, over half of all candidates were successful and were given 2 marks.

Question 21 (d) (ii)

(ii) State the **functional group** in methanol.

.... **[1]**

Misconception

A common misconception was stating the function group as 'alcohol'.

Question 21 (e)

(e) Methanol can be oxidised to methanoic acid.

State the **oxidising agent** used in this reaction.

.... **[1]**

This question was quite challenging for the majority of candidates. Only high attaining candidates were able to state that potassium manganate(VII) is the oxidising agent. Oxygen was the most common incorrect response.

Question 21 (f) (i)

(f) Methanoic acid is a carboxylic acid.

Carboxylic acids react with alcohols to form an ester and one other product.

(i) What type of reaction is this?

Tick (✓) **one** box.

Addition ☐

Condensation ☐

Decomposition ☐

Neutralisation ☐

[1]

Most candidates correctly identified the reaction as a condensation reaction.

Question 21 (f) (ii)

(ii) State the name of the other product in this type of reaction.

.... **[1]**

Water was usually correctly given as the answer; however, hydrogen was a common incorrect response.

Question 22 (a)

22 Group 7 elements (halogens) react with halides in solution.

Chlorine reacts with potassium bromide to form potassium chloride and bromine.

$Cl_2(g) + 2KBr(aq) \rightarrow 2KCl(aq) + Br_2(aq)$

(a) Describe what you would **observe** in the reaction.

.... **[1]**

Some candidates stated the type of reaction (displacement) rather than the correct observation. Responses stating that fizzing or a precipitate would be observed were also common, as were statements that there would be a colour change without describing the colour change.

Question 22 (b) (i)

(b) This is the half equation that shows what happens to chlorine.

$Cl_2 + 2e^- \rightarrow 2Cl^-$

(i) Explain why this half equation shows reduction.

.... **[1]**

Most candidates correctly stated that electrons are gained.

Question 22 (b) (ii)

(ii) Write the **balanced half** equation for the reaction of the bromide ions.

.... **[2]**

Lots of candidates found it difficult to give the correct response for this question. Less successful responses gave the equation for the reverse reaction, i.e. $Br_2 \rightarrow 2Br^- - 2e^-$.

OCR support

When carrying out PAG C1 – Reactivity trends of halogens it would be appropriate to take time to reinforce the half equations involved too. This practical group can be used to reinforce the knowledge assessed in topics C3 and C4.

Question 22 (c)

(c) Chlorine displaces bromine from potassium bromide because chlorine is more reactive than bromine.

Explain why chlorine is more reactive than bromine.

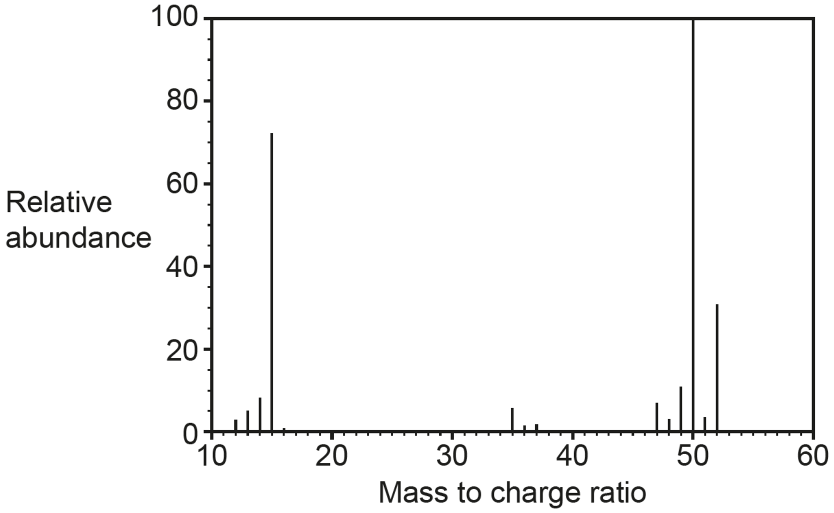
....

.... **[2]**

Successful responses to this question explained that chlorine has a greater attraction between the nucleus and the incoming electron (because chlorine has fewer shells) and so gains electrons more easily. Lower attaining candidates simply stated the trend in reactivity down the group or referred to chlorine losing electrons.

Question 22 (d)

(d) The diagram shows the mass spectrum for a compound containing chlorine.



State the **relative molecular mass** of this compound.

.... **[1]**

A wide range of values were seen, almost always related to peaks on the spectrum with 50 being the most common incorrect response.

Question 22 (e)

(e) Instrumental methods of analysis, such as mass spectrometry, have advantages over simple chemical methods of analysis.

State **two** advantages of instrumental methods of analysis.

1 ....

....

2 ....

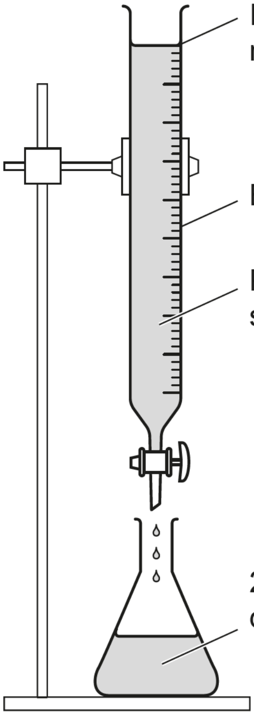
....
[2]

Most candidates scored 2 marks for this question. 'Precise' was however a common non-scoring response.

Question 23 (a)

23 A student plans a titration experiment.

The diagram shows some of the apparatus they use.



(a) At the end of the titration, the student reads the final volume reading from the top of the meniscus instead of from the bottom of the meniscus.

How does the measured volume of potassium hydroxide compare to the actual volume?

Tick (✓) **one** box.

The measured volume will be greater than the actual volume. ☐

The measured volume will be smaller than the actual volume. ☐

The measured volume will be the same as the actual volume. ☐

[1]

'The measured volume will be greater than the actual volume' was a commonly chosen distractor.

Question 23 (b) (i)

(b) The student uses a potassium hydroxide solution with a concentration of 0.100 mol/dm^3 to neutralise the 25.0 cm^3 of dilute sulfuric acid.

The table shows the student's results.

Titration number	**1**	**2**	**3**	**4**
Final burette reading (cm^3)	24.1	26.6	26.0	26.8
Initial burette reading (cm^3)	0.0	1.5	2.1	2.8
Titre (volume of potassium hydroxide solution used) (cm^3)	24.1	25.1	23.9	24.0

(i) Calculate the average titre using the student's concordant results.

Average titre = ... cm^3 **[1]**

Lower attaining candidates calculated the average of all 4 results, including the anomalous result in their calculation.

Question 23 (b) (ii)

(ii) This is the equation for the reaction in this experiment.

$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

Calculate the concentration of sulfuric acid **in g/dm^3**.

Relative atomic mass (A_r): H = 1.0 O = 16.0 S = 32.0

Concentration of sulfuric acid = ... g/dm^3 **[5]**

Around a quarter of candidates were given all 5 marks. Higher attaining candidates were able to calculate the concentration of sulfuric acid in g/dm^3. Error carried forward was given from an incorrect titre in part (b) (i).

Assessment for learning

Examiners use **bold type** to draw the candidates' attention to key aspects of a question.

Despite the emboldening of '**in g/dm^3**' in this question, many candidates calculated the concentration in mol/dm^3.

Exemplar 3

$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

Calculate the concentration of sulfuric acid **in g/dm³**.

Relative atomic mass (A_r): H = 1.0 O = 16.0 S = 32.0

mol/dm3 $\xrightarrow{\times M_r}$ g/dm3

tire = 24/1000 = 0.024 dm³

25/1000 = 0.025 dm³

conc = moles/vol

moles = conc × vol.

	KOH	H_2SO_4	K_2SO_4	H_2O
Ratio	2	1	1	2
Conc	0.1	0.048		
Vol	0.024	0.025		
moles	2.4×10^{-3}	1.2×10^{-3}		

$\rightarrow \frac{2.4 \times 10^{-3}}{2}$

0.048 mol/dm³ → g/dm³

$H_2SO_4 = ((1 \times 2) + (32) + (16 \times 4)) = 98$

0.048 × 98 = 4.704 g/dm³

Concentration of sulfuric acid = ...4.704.......... g/dm³ **[5]**

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 moles of potassium hydroxide. They have appreciated the mole ratio and correctly calculated the moles of sulfuric acid, going on to use this to calculate the concentration of the acid. The candidate has then calculated the relative molecular mass of sulfuric acid and used this to convert the concentration in mol/dm³ to g/dm³.

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