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GCSE (9-1)

Examiners' report

TWENTY FIRST CENTURY SCIENCE CHEMISTRY B

J258
For first teaching in 2016

J258/03 Summer 2018 series

Version 1

Contents

Introduction

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

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

Paper J258/03 series overview

J258 03 is the higher tier paper of two papers for the new revised GCSE examination for Chemistry B. This paper is designed to test the breadth of candidate's knowledge. As such, candidates are tested across the specification with multiple specification areas being assessed within each question in order to test the breadth of candidates' knowledge and understanding. The question style is short answer to target knowledge and understanding predominantly aimed at the assessment objectives AO1 and AO2. The Science for the Twenty First Century suite of specifications include integral Ideas about Science, which are also assessed through the contextualised and issue based question style, where candidates are expected to process unfamiliar information, make informed decisions and solve problems.

Candidate performance

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

- Read and assimilated information given in question stems and applied this when answering the questions.
- Thought about command words and approached questions accordingly, for example by approaching 'Describe how…..' and 'Explain why…' questions differently.
- Answered longer two and three mark questions by considering the number of clear points necessary and ensuring that their marks matched the mark allocations.
- Answered succinctly and clearly.
- Took care to give mathematical answers to the specified number of significant figures or decimal places.
- Took care when balancing or writing equations, ensuring that the equation given was the type demanded (ionic, half, full, balanced).

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

- Repeated information in the question stems or in tables without applying it to answer the problem or question asked.
- Gave partial answers to longer questions so that the available number of marks were not all addressed.
- Gave unstructured, lengthy and rambling answers, some of which went beyond the available space onto additional sheets, which did not make points clearly or contradicted correct statements due to confused statements.
- Did not always read the question carefully so that the answer given did not always match the instructions in the question (for example neglecting significant figures, decimal places, omitting state symbols).
- Made clear but simple errors in equations or mathematical questions which appeared to be within the ability of the candidate to self-correct.

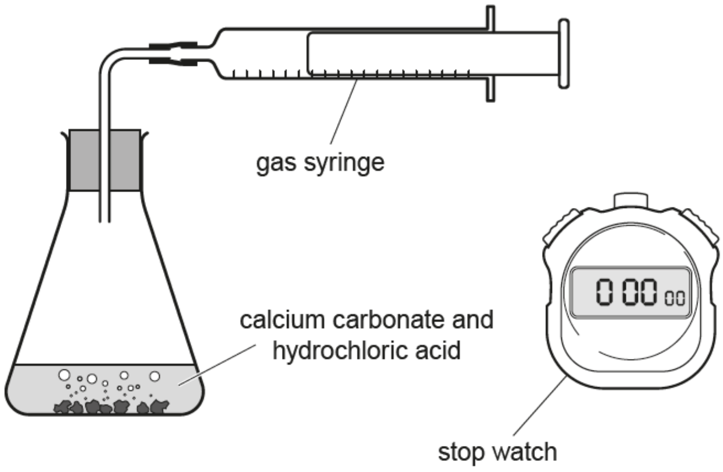
It is further worthy of note that the new specifications address a more complex level of mathematical requirements, in line with national regulations. Some candidates were well prepared to tackle these new requirements. For others, more focus on the newer mathematical content may support their preparation for the examination, for example by ensuring that they are conversant with numbers given in standard form, rearranging equations, working through multi-stage calculations and handling data in different formats.

There was no evidence that any time constraints had led to a candidate underperforming and scripts. Candidates typically answered all questions with few gaps.

Question 1(a)

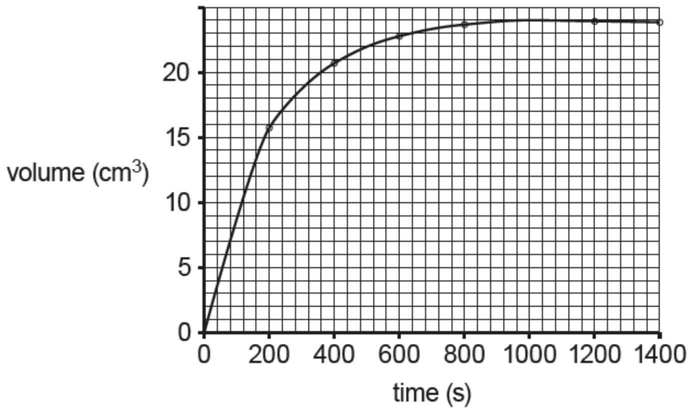
1 Calcium carbonate reacts with excess hydrochloric acid to make carbon dioxide.

Here is the apparatus Jack uses to investigate the reaction.



Jack records the volume of carbon dioxide made every 200 seconds.

Here is a graph of his results.



(a) Use the graph to calculate the rate of reaction over the first 100 s.

Rate = ... cm^3/s **[2]**

Most candidates correctly read the graph to state the volume of gas given off in 100s. Most, but not all, used their value to correctly calculate rate by dividing by 100.

Question 1(b)

(b) Amaya wants to repeat Jack's experiment.

She uses the same mass of calcium carbonate.

She uses the same volume and concentration of hydrochloric acid.

Which **two** other factors does she need to keep the same?

1 ....

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

Most candidates gained a single mark for identifying one control variable. Others restated controls already identified in the question, such as 'mass of calcium carbonate' or 'concentration'.

Question 1(c)

(c) Jack repeats his experiment with more concentrated hydrochloric acid.

He keeps **all** other factors the same. The rate of reaction is faster.

Explain why.

Write about particles in your answer.

....

....

.... **[2]**

Approximately half of the candidates gained at least one mark; candidates found this part question challenging. Some answers discussed 'particles colliding' without referring either to particle density or to collision frequency. Others discussed particles moving faster or having more energy, which does not relate to a change in concentration but rather a change in energy.

AfL For raised concentration, the important points are that particles are *closer together* so collide *more frequently*. When discussing particle collisions, candidates need to discuss *frequency* of collisions rather than only 'more collisions'. Also, candidates need to exclude points about changes in energy (which relates to temperature) when talking about changes in concentration. So candidates should avoid discussing particles moving faster, or having more energy, as these are not relevant to concentration.

Key:

AfL Some guidance to offer for future teaching and learning practice.

Question 1(d)

(d) 0.10 g of calcium carbonate makes 24 cm^3 of carbon dioxide.

Jack uses 0.070 g of calcium carbonate.

What volume of carbon dioxide does he make?

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

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

Most candidates worked out the volume, usually by using a ratio method. Some forgot or missed the instruction to 'give your answer to 2 significant figures'.

AfL

The new specifications test the ability for candidates to round mathematical answers to a given number of significant figures or decimal places. Candidates need to 'watch out' for these instructions in calculations and make sure that they are followed.

Question 2

2 Fizzy water can be found naturally.

The water is fizzy because it contains dissolved carbon dioxide gas. The carbon dioxide comes from the decomposition of rocks that contain carbonate compounds.

One compound found in rocks is magnesium carbonate.

Ali investigates the decomposition of magnesium carbonate by heating a small amount in a test tube. This is the equation for the reaction.

$MgCO_3(s) \longrightarrow MgO(s) + CO_2(g)$

(a) Ali weighs the test tube before and after heating.

The mass of the test tube after heating is less.

Ali says that this means the **law of conservation of mass** is not correct.

Explain why Ali is **wrong**.

....

....

.... **[2]**

Almost all candidates knew that the mass change was due to the escape of carbon dioxide gas. The law of conservation of mass was not always fully explained. Better answers explained the idea that overall there is *no overall total* change in mass, leading to two marks.

Question 2(b)

(b) Calculate the atom economy for the production of carbon dioxide in this reaction.

Use the formula: $\text{atom economy} = \dfrac{\text{mass of atoms in desired product}}{\text{total mass of atoms in reactants}} \times 100\%$

Give your answer to **1** decimal place.

Atom economy = ... % **[4]**

Most candidates substituted into the formula to give an atom economy. The most common reasons for only scoring partial marks were to think that magnesium oxide was the useful product (rather than carbon dioxide) or to give answers to more than one decimal place.

Question 2(c)(i)

(c) In theory, 42.0 g of $MgCO_3$ loses 22.0 g of carbon dioxide when it completely decomposes.

Ali heats 4.2 g of $MgCO_3$.

(i) Calculate the mass of carbon dioxide lost when 4.2 g of $MgCO_3$ completely decomposes.

Mass = ... g **[1]**

Question 2(c)(ii)

(ii) In Ali's experiment, the mass of carbon dioxide lost is 1.8 g.

Calculate the percentage yield of carbon dioxide in Ali's experiment.

Percentage yield = ... % **[1]**

A very high proportion of candidates answered (c) (i) correctly. In addition, very few candidates omitted a response, showing that all candidates are confident to use reacting ratios to calculate masses from an equation. Although fewer went on to correctly calculate percentage yield for (c) (ii), most showed some understanding of the necessary method. Again, very few omitted this part question.

Question 2(d)

(d) Magnesium oxide, MgO, is an ionic compound.

Draw a 'dot and cross' diagram for the ions in magnesium oxide.

Show the outer electron shells only.

[2]

Candidates found this difficult and did not typically draw charged ions. They did usually try to show complete outer shells. Many attempted to draw covalent shared electrons to hold the atoms together. Others showed the atoms before bonding with arrows to show that electrons would be transferred, without showing the final arrangements of electrons in the ions. Some who drew correct ion arrangements of electrons omitted the charges on the ions.

Question 3(a)

3 The table shows the properties of three polymers.

Polymer	Relative breaking strength	Flexibility	Temperature at which it softens (°C)
A	very high	fairly flexible	250
B	low	very flexible	70
C	fairly low	stiff	150

(a) A firm wants to make cups to hold boiling water.

Discuss the suitability of **each** polymer.

....

....

....

....

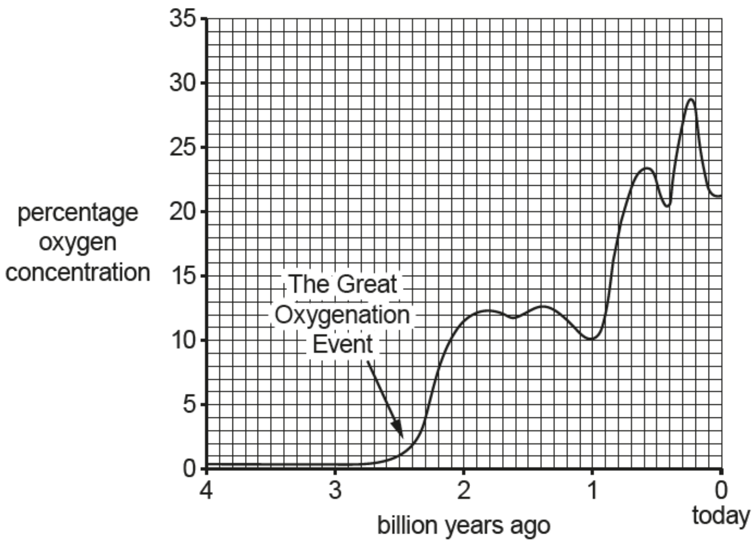
.... **[3]**

In answering this type of question, candidates need to ensure that they make clear statements about the suitability of the polymers, rather than restate the data from the table. For example 'A has a very high breaking strength, is fairly flexible and softens at 250°C' restates the data without discussing the suitability. To improve this answer, candidates need to explain how these properties affect the polymer's ability to make a cup to hold boiling water, for example 'A can hold boiling water because it softens above 100°C'.

Question 4(a)(i)

4 The percentage of oxygen gas in the Earth's atmosphere has generally increased over time.

This graph shows the percentage oxygen concentration in the Earth's atmosphere over the last 4 billion years.



(a) (i) Describe how the oxygen content of the Earth's atmosphere has changed during the last four billion years.

....

....

.... **[2]**

The main point about this question is 'Describe how…..'. Candidates sometimes tried to 'Explain why….' (which overlaps with a later question). The best answers discussed that the oxygen content was low until (approximately) 2.5 billion years ago, and showed a fluctuating increase since then. This type of question is best tackled by describing the overall trend, and adding important values (for example the timing of the start of the increase). Answers such as 'it increases' do not give the necessary detail of description that the pattern on the graph shows.

Question 4(a)(ii)

(ii) The concentration of oxygen has increased from two billion years ago to today.

By what factor has it increased?

Factor = ... **[1]**

The word 'factor' was difficult for some candidates. Some wrote 'photosynthesis'. The word 'factor' has a mathematical meaning and is often applied to increases, particularly those which can be read from graphs.

Question 4(a)(iii)

(iii) Explain what caused the sudden increase in oxygen concentration 2.5 billion years ago and explain why the concentration did not continue to rise.

....

....

.... **[2]**

Most candidates knew that photosynthesis was the important factor in the increase. Some also identified respiration as the main 'balancing' factor. Some confused the two processes, either thinking respiration produced oxygen or that it was respiration of plants themselves which eventually created a balance.

Question 5(a)

5 Ling carries out an investigation of the halogens.

(a) Ling reacts some chlorine solution with a solution of potassium bromide.

The solution turns brown.

Explain why.

Include an **ionic** equation in your answer.

....

....

....

.... **[3]**

Most candidates knew that chlorine is more reactive than bromine and many went on to explain that this means that bromine is displaced, causing the brown colour. The ionic equation was the main discriminatory mark, with only the higher ability candidates giving a correct equation. Common errors were incorrect formula (such as 2Br) or attempting to write full equations which included the potassium ions.

Exemplar 1

$Cl^- + K^{2+}Br_2^{1-} \rightarrow KCl_2 + Br^-$

chlorine is more reactive as halogens are more reactive at the top so it displaces bromine and bromine as a liquid is orange/brown. **[3]**

This candidate knows that chlorine is more reactive than bromine [1] and that bromine is displaced (giving an orange-brown colour) [1]. Notice, however, that the ionic equation contains potassium and has several incorrect formulae, including incorrect formulae for the two halogens involved in the reaction. This was a typical common error.

Question 6(a)

6 Nanoparticles of cerium oxide, CeO_2, are added to diesel fuel.

They act as a catalyst for the combustion of the fuel.

(a) Describe a property of nanoparticles that makes them good catalysts.

....

....

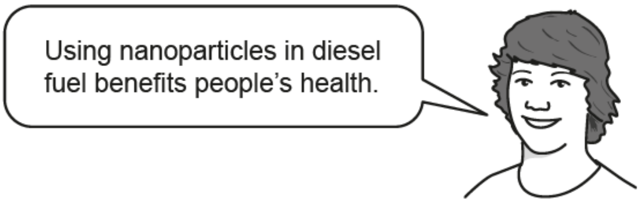
.... **[1]**

The high surface area to volume ratio of nanoparticles was very well known.

Question 6(b)

(b) The addition of nanoparticles allows more complete combustion of the fuel.

Kai talks about nanoparticles in diesel fuel.



Evaluate Kai's statement.

In your answer give arguments **for** and **against** the use of nanoparticles.

....

....

....

....

.... **[3]**

Almost all candidates were able to give arguments either for or against nanoparticles. Most either stated one of the benefits of ensuring complete combustion by identifying one of the products of incomplete combustion (such as carbon monoxide) and linking this to a health issue (such as toxicity). Many candidates also know that the health effects of nanoparticles are not yet fully known. In answering this type of question, candidates are advised to ensure that they answer both 'sides' of the argument rather than giving too much detail about one 'side' only.

Question 6(d)

(d) A nanoparticle has a volume of 8×10^{-27} m.

A molecule has a volume of 4×10^{-30} m.

Estimate how many **moles** of this molecule there are in the nanoparticle.

Number of moles = ... mol **[3]**

Standard form is one of the mathematical requirements which may be less familiar to GCSE candidates. However, many correctly calculated that there are 2000 molecules in the nanoparticle. Fewer quoted the correct number of particles in a mole and only the higher ability candidates reached the final answer. This meant that this question discriminated well.

We have adjusted the mark scheme to allow for a typo within this question.

AfL

In the new specification, candidates need to understand standard form and to recall Avogadro's number.

Question 7(a)(ii)

(ii) Use ideas about rates to explain what is happening when the reaction reaches dynamic equilibrium.

....

.... **[2]**

Most expressed some idea of stability at equilibrium. More able candidates stated that the reaction is reversing or going both ways. Some went on to explain that the rates of the forward and backward reactions are equal. In some answers, the explanations were unclear, for example stating 'both reactions are at the same rate' without clearly stating that 'both reactions' means that one is going in each direction.

Question 7(b)(ii)

(ii) The scientists discuss increasing the pressure on the reaction.

Describe and explain the effect on the equilibrium position.

....

....

.... **[2]**

Candidates often expressed some understanding that an increase in pressure favours the side with fewer moles. Application of this principle to this particular equation is very challenging. Only the higher ability candidates recognised that the number of moles of gas on each side were equal so that there is not overall effect. Some candidates introduced the idea of rates into the answer, rather than focussing on equilibria.

Question 7(c)

(c) There are several ways of making nitrogen compounds from nitrogen gas in industry.

Give **two** reasons why scientists may choose this reaction and **one** against.

Reason for ....

....

Reason for ....

....

Reason against ....

....
[3]

In order to answer this question, candidates need to refer back to the equation and information in the question. Candidates often made statements which were true, but did not fit closely to the question. For example, some discussed why nitrogen compounds are needed (for fertilisers etc), which is true for all processes. Others made statements which did not quite meet GCSE standard, for example 'nitrogen is free'. Higher scoring answers referred more emphatically to the process described in the stem of the question, stating that the high temperature was a 'reason against' or that the reversible nature of the reaction meant that the yield could not reach 100%. More detailed reasons 'for' included the high atom economy, or the fact that the raw materials are available in the air.

Question 8(a)(i)

8 Manganese is a metallic element.

(a) Manganese is made by heating manganese oxide, MnO_2, with carbon.

Carbon monoxide is also formed.

(i) Write a **balanced chemical** equation for this reaction.

Include state symbols in your equation.

.... **[2]**

AfL

When asked to write an equation, candidates need to check that they know what type of equation they are asked for (ionic, balanced, word, half equation) and also whether they need to include state symbols. A relatively common shortcoming for this question was to omit either the balancing or the state symbols. In addition, candidates need to check the information given, a further misconception was to give CO_2 as a product. This error also shows that candidates have not taken time to self-correct their responses. The question stem instructs candidates that carbon monoxide is a product.

Exemplar 2

$MnO_2 + 2C \rightarrow Mn + 2CO$ ✓ **[2]**

Although this equation shows correct formulae and balancing [1] the candidate has missed the instruction to 'Include state symbols' leading to only one mark. A relatively common error was to miss this instruction and similarly to miss the significant figures and decimal places instructions in the mathematical questions.

Exemplar 3

$2Mn + MnO_2 \rightarrow MnO_2 + CO_2$ **[2]**

In this case there are two errors, both of which could have been 'self corrected' by the candidate has (s)he re-read the information given. The information states that manganese oxide is heated with carbon. It further states that carbon monoxide is formed. Neither carbon nor carbon monoxide is given in this equation. The instruction to 'include state symbols' has also been ignored. Therefore no marks could be credited.

Question 8(a)(ii)

(ii) Explain why carbon can be used to extract manganese from its compounds.

Use ideas about reactivity and reduction in your answer.

....

....

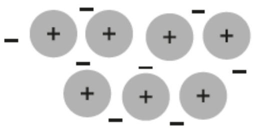
.... **[2]**

Almost all candidates knew that either carbon is more reactive than manganese or that manganese is reduced. This led to most candidates earning at least one mark.

Question 8(b)

(b) Explain how the atoms are held together in a metal.

Refer to this diagram in your answer.



....

....

....

.... **[3]**

Most candidates correctly identified the negative particles as electrons. Some thought that they were negative ions.

Misconception A very common misconception is that the '+' particles in a metal structure are positive protons. Furthermore, there is confusion (which also occurs in later questions about ionic and covalent bonding) about the various types of bonds. 'Intermolecular forces' is a term often used for any type of force, even for those in a metal.

Exemplar 4

Becaus the protons are attracted to the electro so are bound together by force.

This answer does show correct identification of the negative charges in the diagram (electrons) for one mark. However, the candidate believes the positive charges to be protons, so the description given is that of an atom rather than a metal structure, so only one mark credited.

Question 9(b)(i)

(b) Jane looks at the emission spectrum of compound **A**.

(i) Describe what an emission spectrum looks like.

....

....

.... **[2]**

Question 9(b)(ii)

(ii) Describe how Jane could use the spectrum to confirm her answer to **(a)**.

....

.... **[1]**

In both these part questions, candidates knew that colours are seen. Some answers described 'looking at colours' but did not make it clear how emission spectra are different from looking at colours in a flame test. So such answers state 'you would see colours' in (i) and 'you need to match colours' in (ii). Higher ability candidates described how emission spectra show (coloured) lines which can be matched up to reference samples to identify the components of a mixture or element.

Question 9(c)(ii)

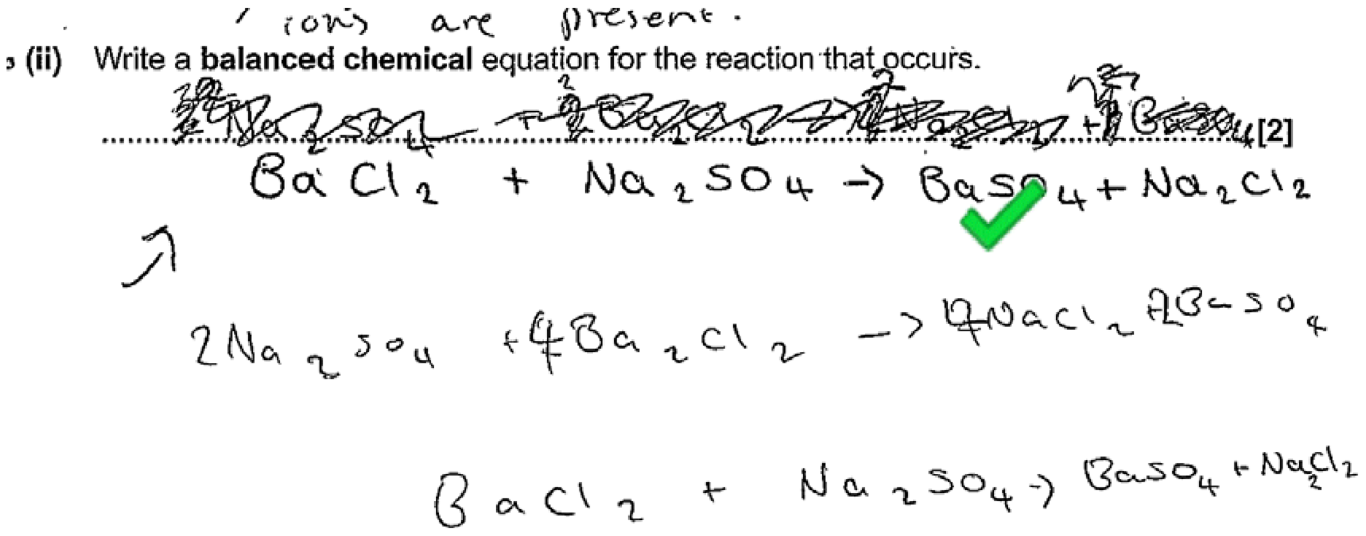
(ii) Write a **balanced chemical** equation for the reaction that occurs.

.... **[2]**

Most gave a correct formula for one of the products.

Misconception Some candidates changed the formula of sodium chloride (which is very familiar to most candidates) in order to balance the equation.

Exemplar 5



This answer gains one mark for a correct formula of a product ($BaSO_4$). However, the candidate has attempted to balance the equation by changing the formula of NaCl to Na_2Cl_2. This was a common error. Clearly the candidate knows the formula of sodium chloride, but is not sure how to show that there are two relative formula mass units in the equation.

Question 10(b)

(b) This is an equation for the overall reaction that happens when water is electrolysed.

2H–O–H ⟶ 2H–H + O=O

Bond	Energy change (kJ/mol)
H–H	434
O=O	498
O–H	464

Use data in the table to calculate the energy needed to break and make bonds during the reaction.

Use your answers to calculate the energy change of the reaction.

Energy change = ... kJ/mol **[3]**

Most candidates knew that the basic method for this question is to total the energy needed for bond breaking and bond making and subtract one from the other. Where full marks were not earned, this was usually due to either arithmetical errors, or in errors 'counting bonds'. Another reason for incorrect answers was to take the final value for 'bonds broken' from the value for 'bonds formed' rather than vice versa. Error carried forward was allowed both within this calculation and for its effect on the direction of enthalpy change in (c).

Question 10(c)

(c) Complete the reaction profile for the electrolysis of water.

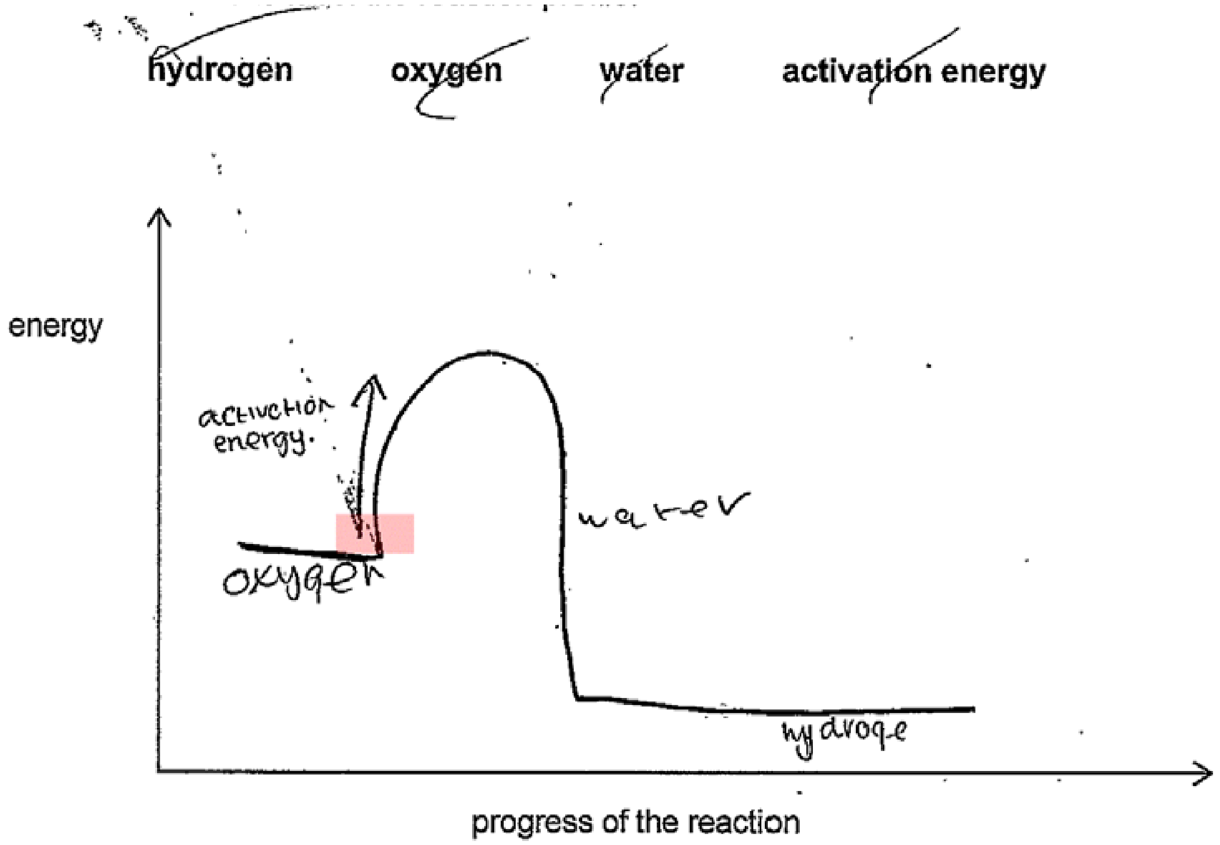
Use these words to label the reaction profile.

hydrogen **oxygen** **water** **activation energy**

[3]

The shape of the energy profile diagram was usually correctly drawn (with error carried forward from an exothermic value in 10b). Candidates need to take great care to draw their diagrams with attention to fine detail. Reactants and products need to be written on the lines. The activation energy should, ideally, be drawn with an upward facing arrow, and it needs to start level with the reactants and end precisely at the top of the 'hump'. Arrows that are significantly shorter than this will not gain a mark.

Exemplar 6



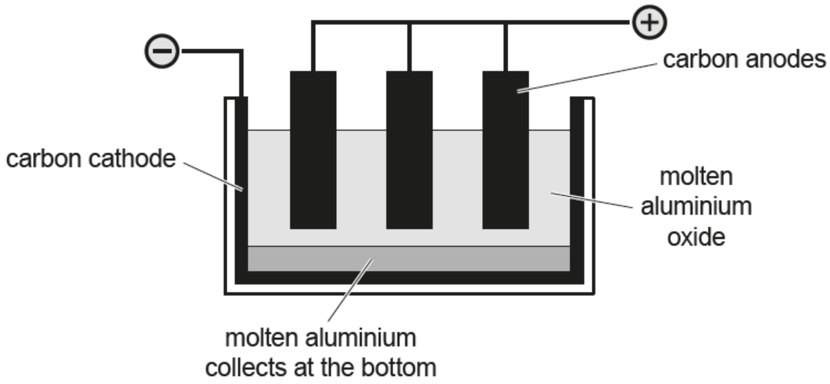
[3]

This exemplar illustrates two common errors. The candidate has drawn a correct energy profile diagram with a 'hump' based on the answer given to 10b (which gave an incorrect negative calculated value for the energy change of reaction) for one mark.

However, the candidate does not know where the product and reactants should be placed on the diagram. Furthermore the activation energy, although positioned in an acceptable place (it would be clearer if it was under the 'hump' however), is incorrect because it is too short at both the top and the bottom of the arrow. The bottom of the arrow should fall in line with the reactant line, the top with the top of the hump.

Question 11(a)

11 Aluminium is made by the electrolysis of molten aluminium oxide.



(a) The ions present in molten aluminium oxide are Al^{3+} and O^{2-}.

Write **half-equations** for the formation of aluminium and oxygen in the electrolysis cell.

Formation of aluminium ....

Formation of oxygen ....
[2]

Half equations are very challenging. Some candidates gave the correct equation for the formation of aluminium. The loss of electrons from two oxygen ions to make a single oxygen molecule was a very difficult equation and only correctly given by very able candidates.

Question 11(b)

(b) Aluminium oxide does not conduct electricity when it is solid.

It conducts electricity when it is molten.

Explain why.

....

....

.... **[3]**

This question links with 8b in that it requires candidates to a model of a molten ionic compound instead of a metal. Almost all candidates knew that movement of particles was important to conduction and that particles can move in aluminium oxide only when it is molten. Answers which earned three marks correctly identified that these particles are ions, which cannot move in solids but can when molten. It was very common that candidates discussed 'moving electrons' in the context of conduction in the molten compound.

AfL

Candidates need to be able to 'compare and contrast' models of metals and in ionic compounds and to state clearly the similarities and differences between them, in particular in relation to the nature of the particles in each model and that the moving particles which enable conduction in each are different.

Exemplar 7

the electrons are delocalised when molten and therefore free to move and carry an electric current. But when solid the electrons cannot move. [3]

This answer gained no credit because rather than describe conduction in a molten ionic compound it gives a partial but confused description of conduction in metals. This confusion between ionic and metallic models for conduction was very common.

Question 11(c)

(c) This is an equation for the overall reaction in the electrolysis cell.

$2Al_2O_3 \rightarrow 4Al + 3O_2$

1.0 kg of aluminium is made in the cell.

Calculate the volume of oxygen (in dm^3 at room temperature and pressure) that is made.

Assume one mole of gas has a volume of 24 dm^3 at room temperature and pressure.

Volume = ... dm^3 **[4]**

Some candidates gained three or four marks through this difficult, multi-stage calculation. Most candidates correctly calculated the formula mass of aluminium oxide. Some used this to calculate the number of moles of oxygen produced. Some recognised the reacting ratio of aluminium oxide to oxygen and used the molar gas volume to calculate the final volume. Although this was a very challenging question there was a very low omit rate. Almost all candidates were able to at least partially work towards the complete calculation.

Question 12(a)

12 Sulfuric acid is used in car batteries.

Mia has a sample of car battery acid that is diluted to $\frac{1}{100}$ of its original concentration.

She measures the concentration of this acid by titration.

(a) This equation shows what happens when pure sulfuric acid is mixed with water.

$H_2SO_4(l) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$

Explain how this equation shows that sulfuric acid is a **strong** acid.

....

.... **[1]**

Some candidates recognised the importance of complete dissociation linked to acid strength. The word 'strong' was misinterpreted, with many candidates focussing on the idea that sulfuric acid is dibasic and so produces more hydrogen ions per molecule.

Question 12(b)(ii)

(ii) Calculate the number of moles in 25.0 cm^3 of 0.100 mol/dm^3 NaOH.

Use the equation: concentration (mol/dm^3) = number of moles of solute ÷ volume (dm^3)

Number of moles = ... mol **[3]**

This question depended on candidates rearranging an equation before substitution. Most were able to do this and earned at least two marks. Fewer recognised the need to convert units of concentration from cm^3 to dm^3.

Question 12(b)(iii)

(iii) This is an equation for sulfuric acid reacting with NaOH.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

Mia finds that 24.5 cm^3 of H_2SO_4 reacts exactly with the NaOH.

Calculate the concentration of the sulfuric acid in the burette in mol/dm^3.

Use the equation: concentration (mol/dm^3) = number of moles of solute ÷ volume (dm^3)

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

Concentration = ... mol/dm^3 **[3]**

Although an equation was given, this calculation was nevertheless very challenging for all but the higher ability of candidates. Candidates needed to use their values from a previous calculation and to remember to both use the reacting ratio in the question, manage the volume unit conversion and to round their answers to two significant figures. Most earned some partial credit for managing at least one stage correctly. Again there was a low omit rate for this difficult question.

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