Qualification Accredited

Oxford Cambridge and RSA

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 3 series overview

The mean mark for the paper was significantly higher than in 2018 (which was the first assessment of the revised qualification). Candidates typically engaged well with questions by using and interpreting the provided information. Candidates handled data in unfamiliar contexts well and showed high order skills in the handling data and numerical processing.

Candidates need to carefully read the information and help given in the stem of questions. There is often instruction there to support and help them to answer fully. For example, in Question 4c the question asked candidates to draw dot-and-cross diagrams for ions. Many drew covalent structures. In Question 6b there were bullets telling candidates what to include. Some omitted the formulae for reactants and products.

In questions where candidates are asked to evaluate information, for example by stating and explaining whether they agree or disagree with a stated view, they need to present evidence which is not only a restatement of the point made. For example, in Question 1cii stating that 'graphite does not produce less than 44 g of $CO_2$' is equivalent to saying 'no'. To earn marks some further explanation is needed. In Question 7a, giving a negative of each bullet point such as 'does not contain a small positive nucleus' is again only saying 'no'. In questions such as this it is important to state points which are not merely a restatement or a negative of the points made in the question.

## Question 1 (a) (i)

**1** Diamond and graphite are two forms of carbon.

**(a) (i)** Fig. 1.1 shows the structure of diamond:

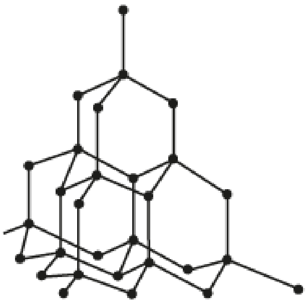


**Fig. 1.1**

Explain why diamond has a high melting point.

........................................................................................................................................

........................................................................................................................................ **[1]**

| |
|---|
| Most knew that the bonds in diamond are strong, with some candidates giving high level answers in terms of the multiple bonds between carbon atoms and the high levels of energy needed to break them. |

| | | |
|---|---|---|
| ? | **Misconception** | Many candidates showed that they had a misconception about what happens during the melting of substances with giant covalent structures by discussing intermolecular forces breaking. A linked error was also evident in Question 3c. |

### Exemplar 1

There are ~~strong~~ strong covalent bonds between each carbon atom. **[1]**

| |
|---|
| This response gained 1 mark. |

### Exemplar 2

Because diamonds have strong intermolecular bonds, meaning more energy is needed to break them. **[1]**

| |
|---|
| This response shows the main misconception in candidates' answers. |

## Question 1 (a) (ii)

**(ii)** **Fig. 1.2** shows the structure of graphite.

Graphite also has a high melting point.

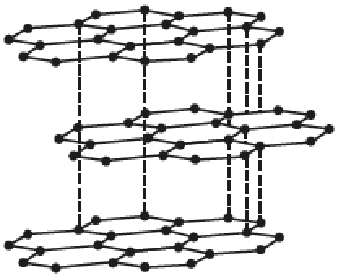


**Fig. 1.2**

Describe and explain **two** other properties of graphite.

Use the structure shown in **Fig. 1.2** to help explain your answers.

Property 1 ..........................................................................................................

Explanation ..........................................................................................................

..........................................................................................................

Property 2 ..........................................................................................................

Explanation ..........................................................................................................

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

The idea of 'property' was modelled for candidates by mentioning melting points. Best answers gave two properties linked to explanations, for example electrical conductivity and ability to 'flake' or lubricating action. However, many candidates seemed unsure of the meaning of the term 'property' and only gave structural points, such as the layered structure or delocalised electrons.

## Question 1 (b)

**(b)** Diamond has a high density.

1.0 g of diamond has a volume of 0.29 $cm^3$.

Calculate the mass of 1.0 $cm^3$ of diamond.

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

Mass = ...................................................... g **[2]**

This part answer was very well answered with most candidates both calculating the correct value and quoting the value to two decimal places.

| | | |
|---|---|---|
| | **AfL** | The new mathematical requirements of the specification demand that specific mathematical skills are met. Where a question asks for a specific number of significant figures it is important to give your answer to that number and to make sure you correctly round your answer if the calculator value is to more than that demanded. |

## Question 1 (c) (i)

**(c)** 12 g of diamond produces 44 g of $CO_2$ when it is burned completely.

**(i)** Calculate the mass of $CO_2$ produced when $1.0 \times 10^{-3}$ g of diamond is burned completely.

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

Mass of $CO_2$ = ...................................................... g **[2]**

This was again well answered. Candidates handled standard form well. The most common reason for not scoring both marks was for a poorly rounded response leading to an incorrect final answer of $3.6 \times 10^{-7}$

## Question 1 (c) (ii)

**(ii)** Jane makes some statements about graphite and diamond:

1 'Complete combustion of 12 g of graphite produces less than 44 g of $CO_2$.'

2 'This is because atoms in graphite are further apart than in diamond.'

Do you agree with Jane's statements?

Explain your answer.

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

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

This was a challenging question for all candidates. Best answers recognised that the amount of carbon in 12 g of either isotope was identical and so that the space between atoms was irrelevant. Many discussed factors that were not relevant to the question, such as the loss of atoms to the surroundings during combustion or that they might incompletely combust.

## Question 2 (a) (i)

**2** Ben uses chromatography to investigate a solid black food dye.

**(a)** Ben tests the solubility of the dye in three solvents.

Here are his results:

| Solvent | Result |
|---|---|
| water | insoluble |
| ethanol | insoluble |
| propanone | soluble |

**(i)** Which of the three solvents are **non-aqueous**?

..................................................................................................................................... **[1]**

All three solvents were often seen as answers. Best answers identified both ethanol and propanone as non-aqueous, but 'propanone' alone was accepted as correct. Some candidates believed water was a non-aqueous solvent. A minority of candidates did not read the names of the solvents carefully and gave the answer 'propane'.

## Question 2 (a) (ii)

**(ii)** Ben uses paper chromatography to investigate the dye.

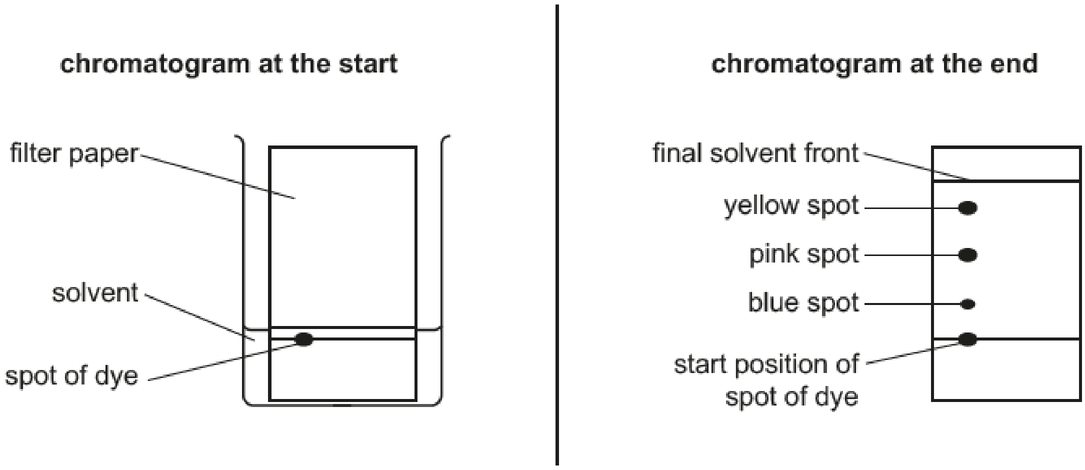
Which of the three solvents should Ben use in his investigation?

.................................................................................................................................... **[1]**

Most correctly chose 'propanone' but some gave 'water' (this may be because this is the solvent they have used in experiments and so it is most familiar).

## Question 2 (b) (i)

**(b)** Here is some information about the experiment:




**(i)** Name the stationary phase.

.................................................................................................................................... **[1]**

Most correctly identified the stationary phase as the filter paper. The most common incorrect answer was the 'starting spot of dye', presumably this was a misconception that the dot is the stationary phase because it does not move.

## Question 2 (b) (ii)

**(ii)** What is wrong with the way Ben set up his experiment?

Explain your answer.

....................................................................................................................................

....................................................................................................................................

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

Most knew that the solvent should not be above the starting dot, but fewer went on to explain their answer effectively. Best answers pointed out that the dot would dissolve in the solvent (and so would not travel up the paper).

## Question 2 (b) (iii)

**(iii)** Which spot has the greatest $R_f$ value in the chromatogram at the end?

Explain your answer.

..........................................................................................................................................

..........................................................................................................................................

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

A very well answered part question. Almost all candidates identified the yellow dot and explained their choice either in terms of Rf values or in terms of the distance travelled by the dot.

## Question 2 (c)

**(c)** Ben thinks the dye is a pure substance. Kareem, another student, disagrees.

Who do you agree with?

Explain your answer.

..........................................................................................................................................

.................................................................................................................................. **[1]**

Although most candidates chose 'Kareem' as being correct, many did not explain their answers. Many candidates repeated the question by stating that the dye 'was not a pure substance' or just stating that 'it is a mixture'. Best answers referred to the chromatogram and stated evidence such as 'the dye has three components' or 'the dye separates into three different colours.

## Question 2 (d)

**(d)** Ben measures the melting point of the dye.

Describe what Ben would see if the dye is pure.

..........................................................................................................................................

.................................................................................................................................. **[1]**

The effect of impurities on melting point was not well known. Some candidates said that the dye would all melt 'at the same time' rather than 'at the same temperature'. Others did not refer to melting point in their answer, but rather referred to a pure substance only giving one dot on a chromatogram.

### Exemplar 3

The melting point would be sharp –

it will have no cange **[1]**

A well-expressed response.

## Exemplar 4

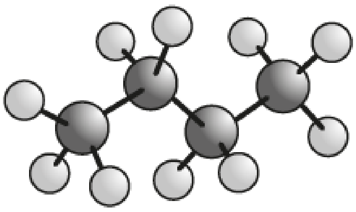
He would see only one spot not 3 as it would contain one element. [1]

This response does not refer to melting point.

## Question 3 (a) (i)

3 'Camping gas' contains butane.

This is a 'ball and stick' model of a butane molecule:



(a) (i) Butane is a hydrocarbon.

Draw a 'dot and cross' diagram for a butane molecule.

[1]

A well answered question, although some candidates missed out some electrons so that the diagram was not fully correct.

## Question 3 (a) (ii)

**(ii)** Chemists use 'ball and stick' models and 'dot and cross' diagrams.

Give **one** advantage of using each model.

'ball and stick'

..........................................................................................................................................

..........................................................................................................................................

'dot-and cross'

..........................................................................................................................................

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

The evaluation of the uses of models is a new syllabus area. When stating advantages and disadvantages of models it is important to make clear points which are unique to each type of model. Statements such as 'it shows how atoms are arranged' is true for both of these models. Best answered mentioned unique advantages of ball and stick models, such as that they show a 3-D arrangement and gave a unique advantage of dot-and-cross, such as they show how electrons are shared to form bonds.

| | | |
|---|---|---|
| | **AfL** | When asked to give advantages and disadvantages, try to make sure your answers clearly make comparisons rather than give advantages which are true for both diagrams or models you are comparing. 'Shows the atoms' for example, is true for both of these models. |

## Question 3 (b)

**(b)** The molecular formula of butane is $C_4H_{10}$.

Calculate the percentage of carbon by mass in butane.

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

Percentage of carbon = ...................................................... % **[3]**

Another calculation question which was well answered. Almost all candidates were able to calculate the relative formula mass of butane and the mass of carbon in the molecule correctly. Most went on to complete a percentage calculation correctly and obeyed the 'two significant figures' instruction to earn all 3 marks.

## Question 3 (c)

**(c)** Propane is another hydrocarbon.

Butane, $C_4H_{10}$, boils at 0 °C.

Propane, $C_3H_8$, boils at −42 °C.

Explain this difference in boiling point.

Use ideas about intermolecular forces in your answer.

........................................................................................................................................

........................................................................................................................................

........................................................................................................................................

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

Best answers identified the difference in size or mass of the two molecules and linked this to the energy needed to overcome or break the intermolecular forces. However, in common with Question 1ci there is confusion between covalent bonds breaking and intermolecular forces breaking during state changes. This question tested a different model to that in Question 1ai.

### Exemplar 5

Butane has a higher melting point because it's a longer hydrocarbon. Meaning it has strong intermolecular forces. It needs a lot of energy to over come the forces. Propane ~~has less~~ is short, so it has weaker intermolecular forces **[2]**

A good clear response.

### Exemplar 6

Butane boils at a much higher temperature than propane as it contains more carbon and hydrogen and therefore more covalent bonds that have to break. So more energy is needed to break the extra covalent bonds in butane **[2]**

This response shows the most common misconception seen. The candidate clearly states that covalent bonds are broken.

| | | |
|---|---|---|
| ? | **Misconception** | Candidates are unsure of the type of bonds or forces that are broken when different types of compound change state. The melting of giant covalent compounds was tested in 1ai and the boiling of simple covalent compounds was tested here. Candidates evidently confuse the two models. |

## Question 4 (a)

**4** This question is about the efficiency of LED light-bulbs in 2015 compared to 2011.

The table shows part of a life-cycle assessment for the two light-bulbs. The numbers in the table compare the energy used to give the same amount of light in a certain time.

| Stage in life cycle | 2011 light (MJ) | 2015 light (MJ) |
|---|---|---|
| **Manufacture** | 343 | 132 |
| **Transport** | 3 | 2 |
| **Use** | 3540 | 1630 |

**(a)** In total, 2015 LED lights use less energy than 2011 LED lights.

Calculate the percentage decrease in energy use at 'manufacture' stage from 2011 to 2015.

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

Percentage decrease = ........................................................ % **[2]**

The calculation of percentage change is a common way to process data. The first stage is the calculation, by subtraction, of the change, followed by dividing by the initial value. Candidates often omitted the first stage so that they were actually calculating the percentage of 2015 compared to 2011 rather than the change. Some candidates calculated the change in the overall use rather than only in the manufacture stage, as asked in the question.

## Question 4 (b)

**(b)** The data in the table does not cover the whole life-cycle assessment.

Describe in detail the **final** stage of the life-cycle assessment.

.......................................................................................................................................

.......................................................................................................................................

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

Most knew that life-cycle assessment are 'cradle to grave' and so discussed the final disposal of the light bulbs, usually mentioning recycling. Fewer discussed that at least some of the components would be landfilled or needed to be disposed of as rubbish. Some gave high level answers discussing the energy used in different stages of recycling such as transport, separation and processing.

## Question 5 (a)

**5** Mendeleev left gaps when he constructed his Periodic Table. He thought elements would be discovered to fill these gaps.

**(a)** Mendeleev left a gap below aluminium.

Later gallium was discovered and fitted this gap.

Give **two** reasons why gallium fitted this gap.

1 .......................................................................................................................................

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

Most candidates showed some understanding that the properties of gallium were involved in its position in the table. Best answers discussed that it belongs in Group 3 because its properties were similar to aluminium and also identified that its mass fitted (typically candidates stated that its mass was 'between zinc and germanium'). Answers which were not sufficient to gain credit suggested more vague points about the properties such as that they were 'similar to surrounding elements' (rather than to a particular group). Other answers gave properties that are true for many elements, such as that it had a 'bigger mass than aluminium' or was 'more reactive than aluminium'. Although both these statements are true they do not securely locate gallium in this one unique position.

## Question 5 (b)

**(b)** When Mendeleev made his Periodic Table he also put some elements 'out of order'.

Which later discovery proved that he was right to do this?

Tick (✓) **one** box.

More properties of the elements were discovered. ☐

Atomic numbers were measured. ☐

Most atoms contain neutrons. ☐

More elements were discovered. ☐

**[1]**

Most answered this correctly by identifying that the measurement of atomic numbers supported Mendeleev's order.

## Question 5 (c)

**(c)** Gallium forms an oxide, $Ga_2O_3$.

Draw a 'dot and cross' diagram for the **ions** in $Ga_2O_3$.

Show outer electron shells only.

**[3]**

Many candidates answered this correctly and gave clear diagrams showing that gallium has an empty (or complete 8) outer shell, that oxygen has  electrons and showed the correct charges. A common misconception (despite the instruction to draw a diagram for the ions) was that gallium oxide is a covalent molecule.

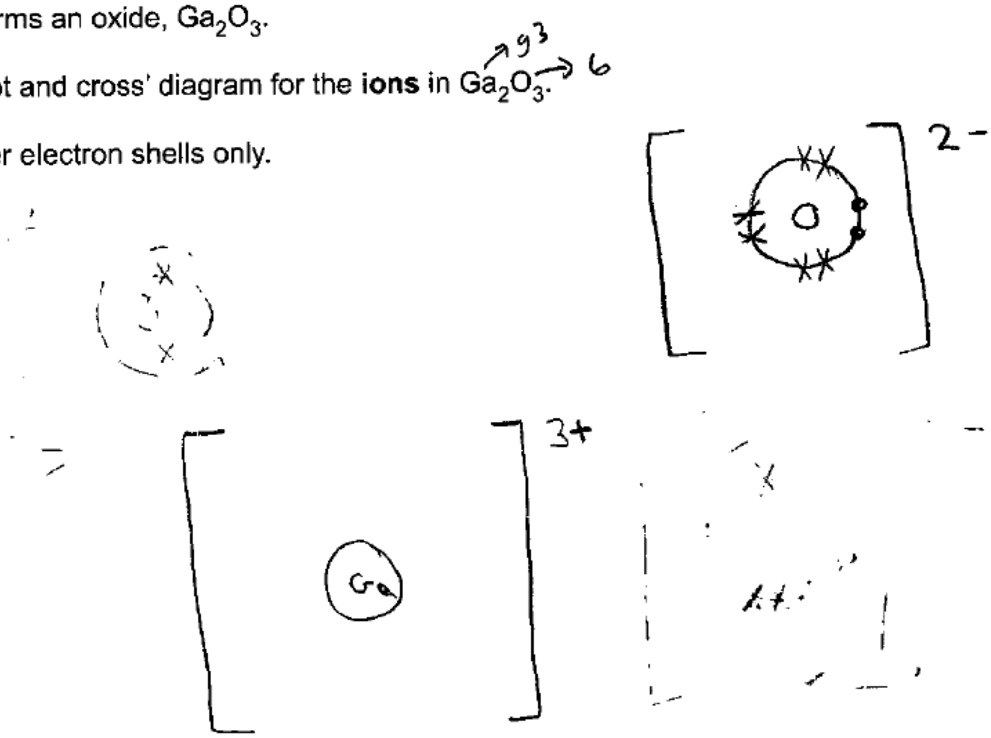
Another common error was to draw the atoms with arrows to show how the electrons would be transferred without showing the final arrangement of the electrons in the ions. The question asked for the ions to be shown, not how they were formed.

## Exemplar 7

**(c)** Gallium forms an oxide, $Ga_2O_3$.

Draw a 'dot and cross' diagram for the **ions** in $Ga_2O_3$.

Show outer electron shells only.




**[3]**

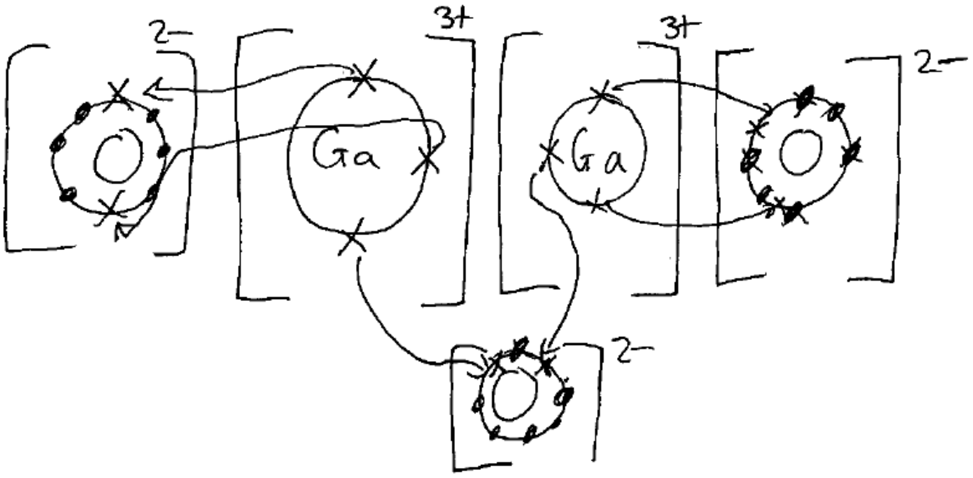
This response clearly shows all features of the ions correctly.

## Exemplar 8

**(c)** Gallium forms an oxide, $Ga_2O_3$.

Draw a 'dot and cross' diagram for the **ions** in $Ga_2O_3$.

Show outer electron shells only.




**[3]**

Despite the arrows, this candidate does not represent the final ion of gallium. The diagram still shows three electrons in the outer shell. This diagram only earns 2 marks

## Question 6 (a)

**6** Some cars use hydrogen fuel cells instead of petrol.

This is the reaction that happens in the hydrogen fuel cell:

$2H_2 + O_2 \rightarrow 2H_2O$

**(a)** Suggest **one** advantage and **one** disadvantage of using fuel cells instead of petrol.

Advantage

..............................................................................................................................................

..............................................................................................................................................

Disadvantage

..............................................................................................................................................

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

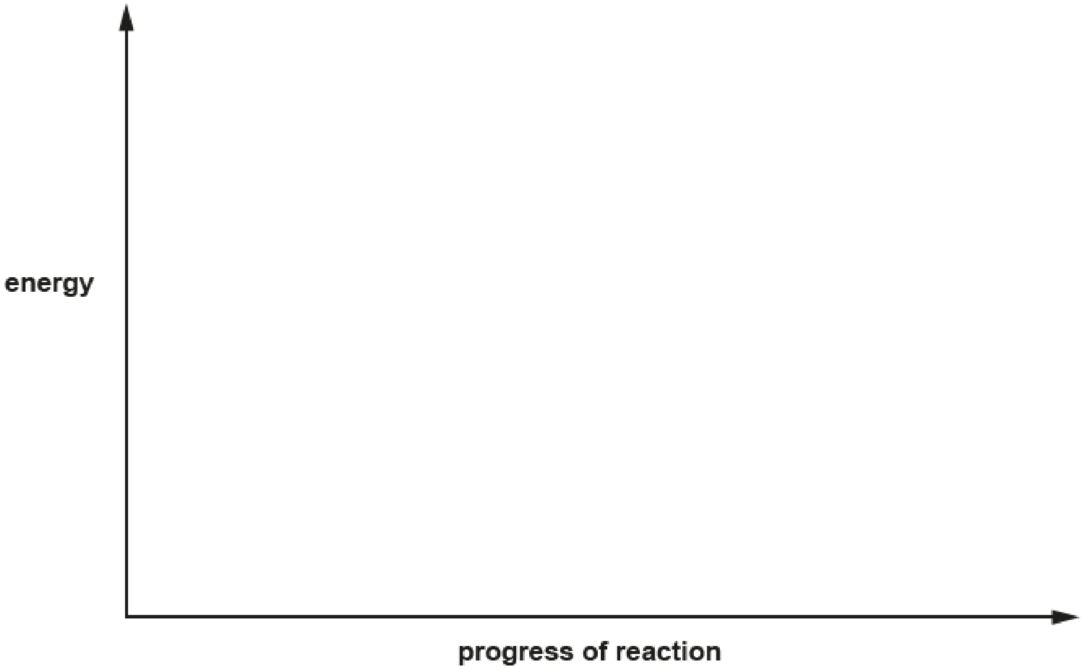
This question discriminated well between candidates. Most made at least one clear point. Most identified that fuel cells do not directly produce carbon or nitrogen based emissions that petrol engines do. Common disadvantages stated included the difficulty of storing of hydrogen due to its gaseous or flammable nature. When marks were not credited, it was usually because answers were vague or only partially made points. Answers which were not accepted included that fuel cells 'produce less pollution' or that 'they are more expensive'.

## Question 6 (b)

**(b)** Complete a reaction profile for the above reaction of hydrogen with oxygen.

On the profile, show:

- the formulae of reactants and products
- the activation energy.




**[3]**

Best answers showed an exothermic reaction, with the formulae of reactants and products and the activation energy drawn carefully with an upward arrow, starting at the level of reactants and ending at the tip of the curve. Some drew an endothermic reaction. Many (despite the bulleted instruction reminding them to do so) omitted the formulae. The arrow for the activation energy needs to be carefully drawn. Arrows which were significantly too short were not given any credit.

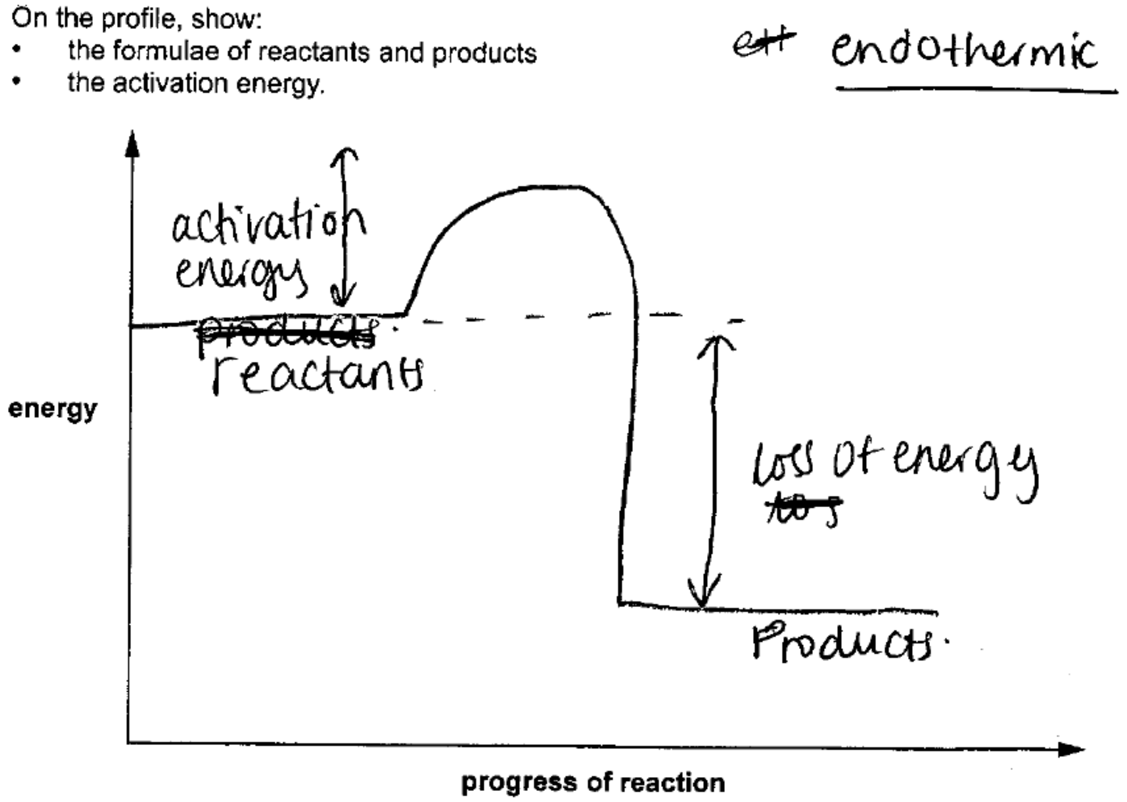
| | | |
|---|---|---|
| | **AfL** | The arrows representing activation energy and overall energy change should be single headed indicating the direction of the energy. In the mark scheme for this series, double headed arrows were allowed. This may not be the case in future series. |

## Exemplar 9

**(b)** Complete a reaction profile for the above reaction of hydrogen with oxygen.

On the profile, show:

- the formulae of reactants and products
- the activation energy.




**[3]**

This candidate gained partial credit for a correct reaction profile shape. Notice that the formulae for the reactants and products are missing and that the activation energy arrow has been drawn significantly higher than the tip of the curve so that it is too long.

## Question 6 (c)

**(c)** Burning 10 g of hydrogen gives out 1200 kJ of energy.

How much energy is given out when 1.0 mole of $H_2$ burns?

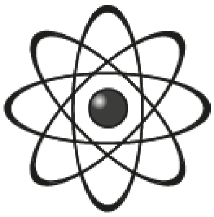
Use the formula: $\text{number of moles} = \frac{\text{mass of substance}}{\text{relative formula mass}}$

Energy = ...................................................... kJ **[2]**

Another well answered calculation. A common error was to use 1.0 as the relative formula mass for hydrogen, but otherwise most candidates calculated the energy correctly.

## Question 7 (a)

**7** This question is about Rutherford's model of the atom.



Rutherford's model describes:
- a small positive nucleus
- the nucleus surrounded by empty space
- electrons orbiting in this empty space.

**(a)** Thomson's 'plum pudding' atom was an earlier model of the atom.

Describe **one** way in which Thomson's model of the atom was different from Rutherford's.

........................................................................................................................................

........................................................................................................................................ **[1]**

In this type of question candidates need to make sure that they give new information rather than repeat the information in the question or turn the statements into negatives. Best answered showed clear evidence of recall of the Thomson model, giving differences such as 'the positive charge is delocalised across the atom' or 'the electrons are spread throughout the atom'. Answers which just gave negatives of the provided information do not earn credit because they do not show any additional knowledge or understanding. Hence 'it does not have a small positive nucleus' (the opposite of bullet 1) or 'it does not have electrons orbiting empty space' (the opposite of bullet 3) do not earn any credit.

| | | |
|---|---|---|
| | **AfL** | In answers where you are asked to say whether you agree or disagree with a statement and to explain your answer you need to use either your own knowledge or provided data in your explanations. Beware of turning the statement around to make a negative statement. You need to add information in your answer to explain why you don't agree. |

## Question 7 (b)

**(b)** Rutherford asked Hans Geiger and Ernest Marsden to do an experiment to test his model.

They fired positive particles at a piece of gold foil.

What did they see that surprised them?

Tick (✓) **one** box.

All the positive particles went straight through. ☐

Some positive particles lost their charge. ☐

Many positive particles 'bounced back'. ☐

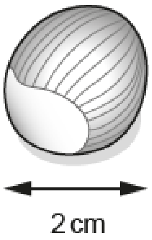
Very few positive particles 'bounced back'. ☐

**[1]**

Most knew that very few particles bounced back. The most common incorrect choice was that many particles bounced back.

## Question 7 (c)

**(c)** A nut has an average diameter of 2 cm.




The diameter of an atom is on average 50 000 times bigger than the diameter of its nucleus.

Estimate the diameter of the nucleus if the atom is as big as the nut.

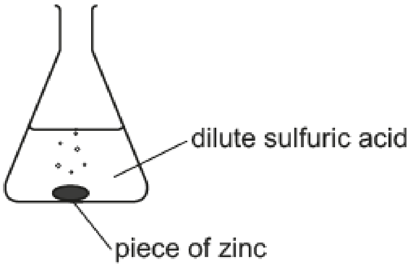
Give your answer in metres **and** in standard form.

Diameter = ...................................................... m **[2]**

Candidates again answered this mathematically based question well. They handled the standard form without difficulty.

## Question 8 (a)

**8** Sundip reacts zinc with dilute sulfuric acid.




This is the equation for the reaction:

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

**(a)** Sundip drops a **piece** of zinc into some dilute sulfuric acid.

She then drops some zinc **powder** into the dilute sulfuric acid.

Which reaction is faster?

Explain your answer.

.......................................................................................................................................

....................................................................................................................................... **[1]**

Almost all candidates identified that zinc powder gives the fastest reaction due to its larger surface area.

## Question 8 (b)

**(b)** Sundip adds some blue copper sulfate solution to the sulfuric acid. She then drops in a piece of zinc.

Sundip thinks copper sulfate is a catalyst.

Describe **two** things that Sundip would observe if copper sulfate is a catalyst.

1 .......................................................................................................................................

.......................................................................................................................................

2 .......................................................................................................................................

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

Ideally, when candidates are asked to respond in terms of observations, the answers should include what they would see. In this case best answered talked about increased rate of fizzing or that the zinc reduces in size more quickly. Although most stated the reaction would be faster, fewer answered at this level and did not give clear observations. Many stated that the catalyst would not be used up. However very few linked this to an observation that the copper sulfate solution remains blue.

## Question 8 (c) (i)

**(c) (i)** Sundip uses 6.5 g of zinc and excess acid. All the zinc reacts.

Calculate the **volume** of hydrogen is made at room temperature and pressure.

Use the formula: $\text{number of moles of gas} = \dfrac{\text{volume of gas in sample}}{24}$

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

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

Volume of hydrogen = ................................................ $dm^3$ **[2]**

This mathematical question proved more difficult than others for many candidates. Many successfully rearranged the equation. However, calculating the number of moles of zinc was more difficult. Many did not do this crucial step but used 6.5 as the molar amount in the equation.

## Question 8 (c) (ii)

**(ii)** Sundip repeats **(c)(i)** with a catalyst present.

How does the volume of hydrogen compare with the volume calculated in part **(c)(i)**?

Give **one** reason for your answer.

........................................................................................................................................

........................................................................................................................................

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

Candidates who recognised that the amount would stay the same usually went on to justify this in terms of the catalyst only affecting rate. Some thought that the volume of hydrogen would increase along with the rate.

## Question 9 (a)

**9** Some countries do not have enough drinkable water.

**(a)** Chlorine is added to water to make it fit to drink.

The test for chlorine gas relies on two properties of chlorine.

Put a (ring) around the **two** correct answers.

acidic

bleaching action

green gas

reacts with metals

toxic

**[2]**

This question asked for the properties of chlorine which link to the test for the gas. Candidates did not always read the question carefully. Many circled two correct properties, but these were not necessarily those which link to the test. Most candidates knew that chlorine is either acidic or has a bleaching action, but not necessarily both.

## Question 9 (b) (i)

**(b)** **(i)** Explain why chlorine is added to drinking water.

.......................................................................................................................

.......................................................................................................................

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

The fact that chlorine kills bacteria was very well known.

## Question 9 (b) (ii)

**(ii)** Give **one** risk of adding chlorine to drinking water.

.......................................................................................................................

....................................................................................................................... **[1]**

Answers here tended to be vague such as 'it is not safe to drink' or 'it is an acid'. Best answers both included a risk (such as its toxicity) and further mentioned that this is only a risk when the concentration is high. Stating this was not necessary to gain the mark, but it revealed that many candidates have a very good understanding of the risks and benefits of using chlorine in drinking water.

## Question 9 (c) (i)

**(c)** Beth adds a solution of sodium bromide to a sample of water.

**(i)** What colour does she see if the water contains dissolved chloride?

........................................................................................................................ **[1]**

The dissolved chlorine confused candidates. The most common answer was 'yellow-green' rather than the correct answer 'orange-brown' which would be the result of the reaction between chlorine and sodium bromide.

## Question 9 (c) (ii)

**(ii)** Write an **ionic** equation for this reaction.

........................................................................................................................

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

This question was very challenging for candidates. Very few produced a fully correct ionic equation. Attempts commonly included the sodium ions and gave incorrect formulae such as Cl for chlorine.

## Question 10 (a) and (b)

**10** Ammonia and its compounds are used world-wide as fertilisers.

Ammonia is made by the Haber process.

This is an equation for the reaction:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

The forward reaction is exothermic.

**(a)** The $\rightleftharpoons$ sign shows that the reaction is 'in equilibrium'.

Which two statements are correct for this reaction at equilibrium?

Tick (✓) **two** boxes.

The reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ has stopped. ☐

There is a mixture of $N_2$, $H_2$ and $NH_3$. ☐

The reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ is going in both directions. ☐

The reaction $2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$ does not happen. ☐

**[2]**

**(b)** Which two statements about the Haber Process are correct?

Tick (✓) **two** boxes.

Nitrogen is the most expensive raw material. ☐

Hydrogen is made from natural gas and steam. ☐

Ammonia is separated and the nitrogen and hydrogen are recycled. ☐

The reaction is faster at low pressures. ☐

**[2]**

These questions were well answered, showing a good understanding both of the Haber process and of reversible equilibrium reactions in general.

## Question 10 (c)

**(c)** In the Haber process a temperature of 450 °C is often used.

Nina says,

'The Haber process should be run at a lower temperature. More ammonia is produced per day at a lower temperature.'

Discuss Nina's statement.

.......................................................................................................................................

.......................................................................................................................................

.......................................................................................................................................

....................................................................................................................................... **[3]**

The key points here are the compromise between yield and rate. Although most candidates appeared to realise this, the words they chose often made it difficult for examiners to securely award marks. As the information mentions 'more ammonia is made per day' a discussion of yield needed to clearly mention yield or explain that it meant total ammonia made from a fixed amount of reactants. Statements about 'more ammonia' or 'less ammonia' were problematic because it was not clear whether candidates were discussing yield or 'per day', which is actually rate.

### Exemplar 10

A lower temperature would increase the yield as it would shift the point of equilibrium to the right, however it is carried out at a higher temperature to speed up the process (increase rate of reaction) **[3]**

This is a good example of a candidate clearly distinguishing between yield and rate. The third mark was not earned because the response did not include a clear statement why 450 °C is chosen (for example by clearly stating that this is a compromise between yield and rate).

## Question 10 (d)

**(d)** Jamal, another student, says,

'Fertilisers that contain ammonium compounds should be banned.'

Give **one** argument for and **one** argument against these types of fertilisers being banned.

.......................................................................................................................................

.......................................................................................................................................

.......................................................................................................................................

.......................................................................................................................................

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

Many candidates gave a good account of the conflicts between producing food and the drawbacks of ammonium fertilisers (such as their effects on water courses). Some answers were too vague, however, making statements which did not make it clear what the issues were. Hence statements such as 'they help plant growth' (which does not link to supply of food) or 'they harm the environment' (without identifying how) were not given credit.

## Question 11 (a) (i)

**11** Mia has three metals, **A**, **B** and **C**, that she reacts with water.

This is what she sees:

Metal **A** Fizzes and reacts quickly.

Metal **B** A few bubbles appear after some time.

Metal **C** Slow fizzing.

**(a) (i)** Which metal forms positive ions most easily?

Give **one** reason for your answer.

.......................................................................................................................................

....................................................................................................................................... **[1]**

Almost all knew that A forms positive ions most easily because it reacts fastest.

## Question 11 (a) (ii)

**(ii)** Metal **A** reacts with water to form $A^{2+}$ ions.

Write the **half** equation for this reaction.

....................................................................................................................................... **[1]**

In common with a previous Question, 9cii, ionic and half equations are not well understood. Although most realised that electrons are involved, few wrote a fully correct ionic equation.

## Question 11 (a) (iii)

**(iii)** Explain whether metal **A** is being reduced or oxidised.

........................................................................................................................................

........................................................................................................................................ **[1]**

Very few candidates correctly stated that A is oxidised because it loses electrons. This difficulty may have been linked to the candidates finding the ionic equation difficult.

## Question 11 (b)

**(b)** Metal **C** goes brown when put in copper sulfate solution, $CuSO_4$.

Metal **C** forms a compound that contains $\mathbf{C}^{2+}$ ions.

Write a balanced symbol equation for this reaction. Include state symbols.

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

This full equation was attempted more successfully than the equations in Questions 9cii and 11aii. However, many did not derive the correct formula for '$CSO_4$'. The most common way to gain a single mark was to show correct state symbols.

## Question 11 (c)

**(c)** Metals conduct electricity.

Describe how the bonding in metals explains this.

........................................................................................................................................

........................................................................................................................................

........................................................................................................................................

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

Most knew that electrons move. Many identified that the electrons in metals are delocalised but did not complete the explanation by mentioning the movement.

## Question 12 (a) (i)

**12** 'Tumsoothe' is a medicine that cures indigestion.

Tumsoothe is a solution of 'sodium bicarbonate', $NaHCO_3$.

Layla puts some Tumsoothe in a beaker and places it on a balance.

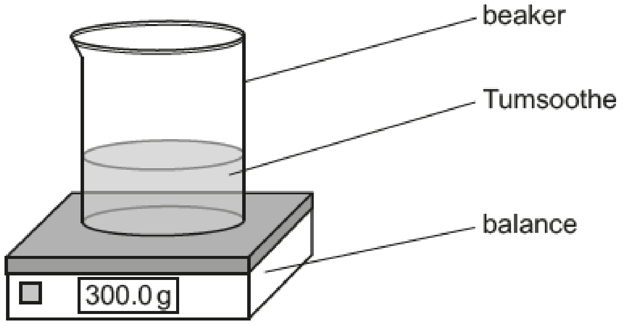



**Fig. 12.1**

She adds dilute hydrochloric acid to the contents of the beaker. $CO_2$ is given off.

**(a)** Layla records the mass of the beaker and its contents every 10 seconds up to 60 seconds.

This is a graph of her results:

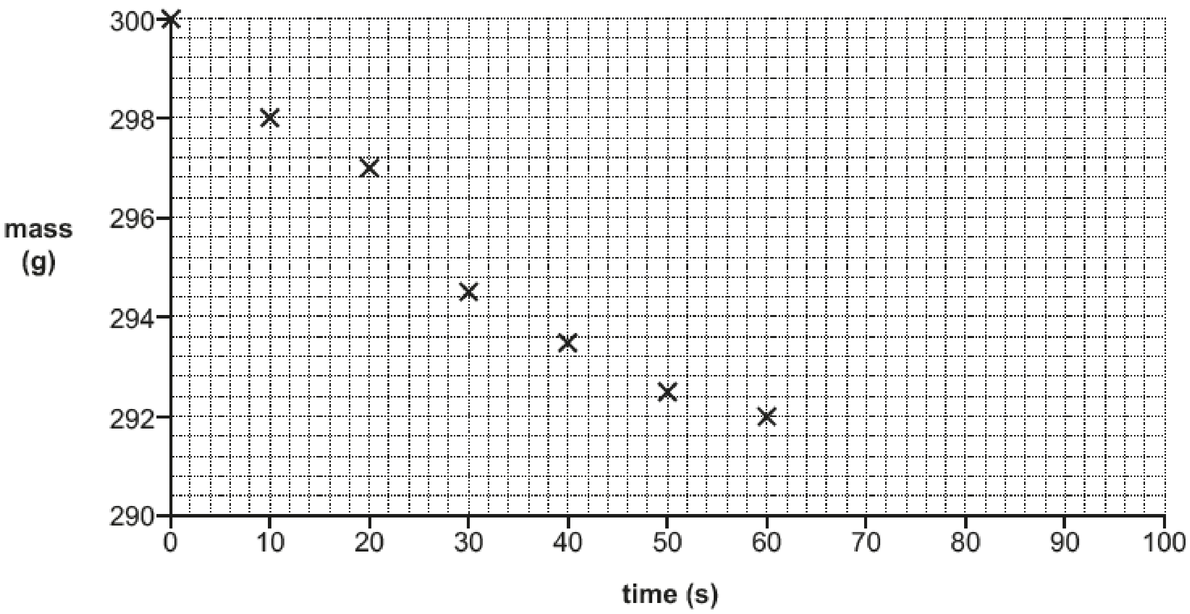



**Fig. 12.2**

**(i)** Draw a curve of best fit on the graph in **Fig 12.2**. **[1]**

Almost all candidates drew a curve of best fit. Some lost this mark because their curve was feathered or broken. A few incorrectly tried to include the outlier in the curve. Candidates are advised to take care to draw a smooth curve without feathering which follows the pattern of the points as closely as possible.

## Question 12 (a) (ii)

**(ii)** Use **Fig. 12.2** to calculate the **initial** rate of reaction.

Initial rate of reaction = ................................................... g/s **[2]**

Most knew that the initial rate could be calculated by using values of mass and time. However, the graph does not start at zero, so to get an appropriate mass measurement it was necessary to do a subtraction to find a mass change in a given time. This was not always done so the rate calculated was incorrect.

## Question 12 (a) (iii)

**(iii)** Describe how the rate of reaction changes with time.

.......................................................................................................................................

....................................................................................................................................... **[1]**

Almost all candidates recognised that the rate decreased over time.

## Question 12 (a) (iv)

**(iv)** Use **Fig. 12.2** to estimate the **total** mass loss in the reaction after 100 seconds has passed.

Explain how you obtained your answer.

.......................................................................................................................................

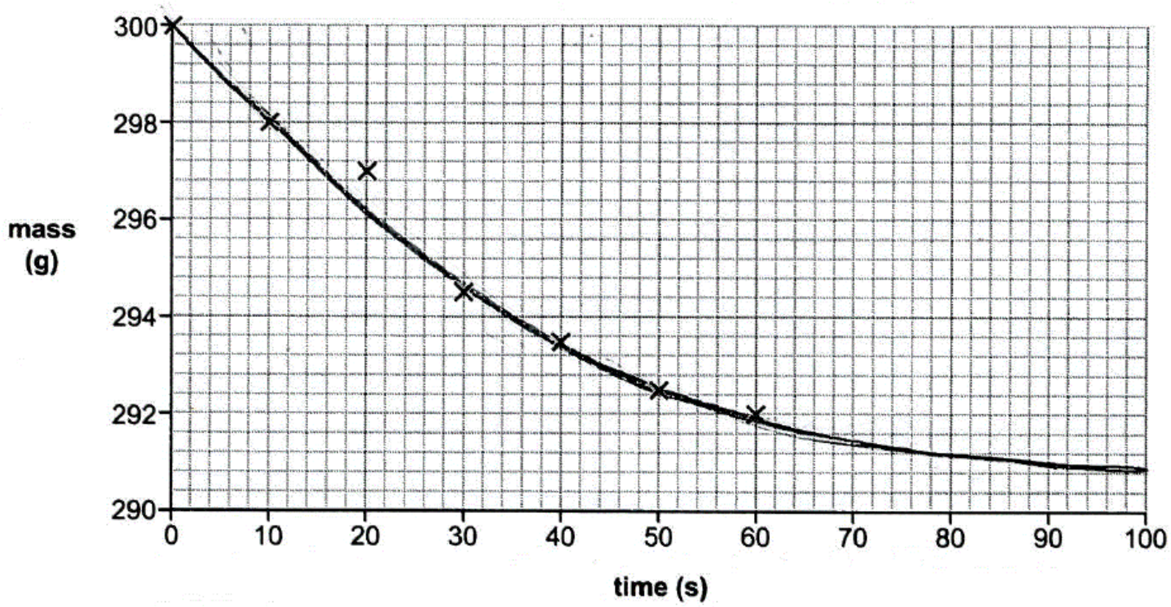
.......................................................................................................................................

.......................................................................................................................................

Total mass loss = ...................................................... g **[2]**

Candidates approached this in two ways. The most straightforward way was to extrapolate the graph and take a reading. Many candidates did this but their extrapolation was not always careful. A common error was to try to extrapolate to the x-axis. Other candidates attempted a mathematical ratio method. This approach did not usually lead to a value within the acceptable range.

## Exemplar 11




**(iv)** Use **Fig. 12.2** to estimate the **total** mass loss in the reaction after 100 seconds has passed.

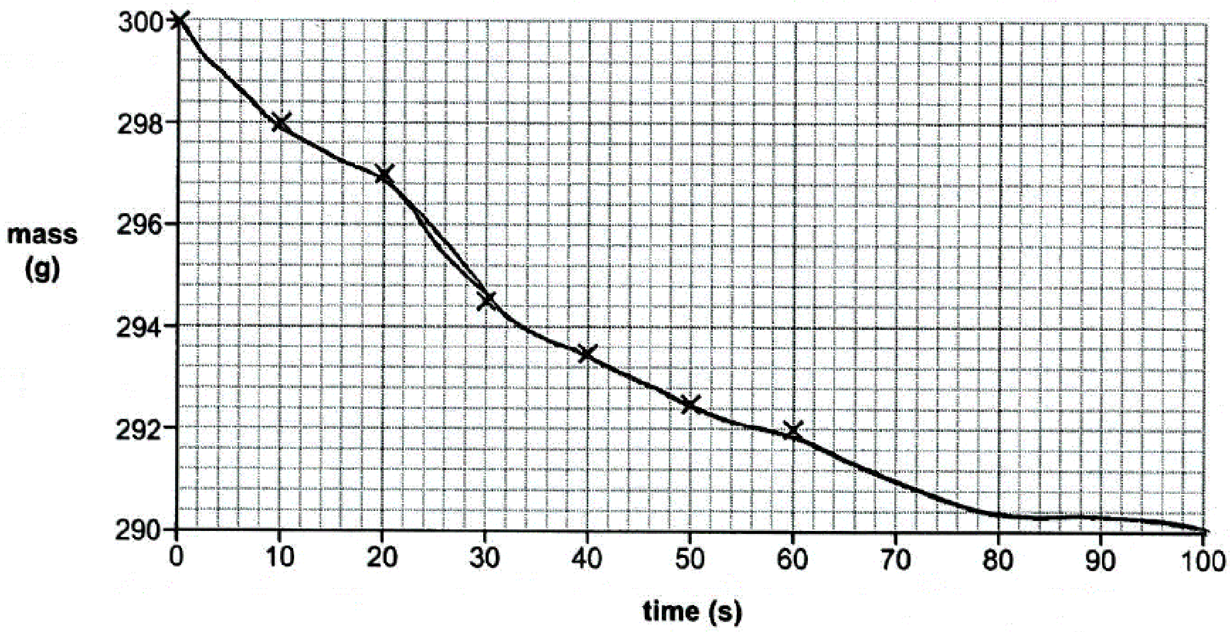
300 − 290.8 = 9.2

Explain how you obtained your answer.

Initial mass was 300 and ~~by extending the~~ on the curve at 100 seconds it is at 290.8. The mass lost is the difference which is 9.2g.

Total mass loss = 9.2 g **[2]**

## Exemplar 12




(iv) Use **Fig. 12.2** to estimate the **total** mass loss in the reaction after 100 seconds has passed.

Explain how you obtained your answer.

........................................................................................................................

........................................................................................................................

........................................................................................................................

Total mass loss = ...................................................... g **[2]**

Contrast these two responses. Exemplar 11 earned marks in both Questions 12ai and 12aiv. Notice that in Exemplar 12 the curve is incorrect and does not earn Question 12ai. Also, the extrapolation incorrectly meets the mass line at 290.

## Question 12 (b) (i) and (ii)

**(b)** Layla does her experiment a second time. She uses an excess of acid and a different volume of Tumsoothe.

8 g of $CO_2$ is given off.

**(i)** Calculate the number of moles of $CO_2$ given off.

Use the formula: number of moles = $\frac{\text{mass of substance}}{\text{relative formula mass}}$

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

Number of moles of $CO_2$ = ................................................ mol **[2]**

**(ii)** This is an equation for the reaction:

$NaHCO_3(aq) + HCl(aq) \rightarrow CO_2(g) + NaCl(aq) + H_2O(l)$

Calculate the **mass** of $NaHCO_3$ that reacts.

Use the formula: number of moles = $\frac{\text{mass of substance}}{\text{relative formula mass}}$

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

Use your answer to **(b)(i)** to help you.

Mass of $NaHCO_3$ = ................................................ g **[2]**

Yet more well answered calculations. Candidates calculated the correct relative formula masses correctly, substituted into the equations and computed the final values successfully.

## Question 12 (c) (i)

**(c)** Layla wants to measure the concentration of $NaHCO_3$ in Tumsoothe.

She titrates her Tumsoothe solution with hydrochloric acid.

**(i)** Layla measures out 25.0 $cm^3$ of Tumsoothe.

What piece of apparatus should Layla use to measure out this volume?

........................................................................................................................ **[1]**

Although the correct answers (pipette or burette) were well known, many candidates gave 'measuring cylinder' as their response. A measuring cylinder cannot measure precisely to one decimal place, and for titration purposes candidates should know that a pipette is the routine apparatus of choice.

## Question 12 (c) (ii)

**(ii)** Layla repeats her titration three times. Her results are shown.

| **Repeat** | **1** | **2** | **3** |
|---|---|---|---|
| **Volume of acid added to neutralise $NaHCO_3$ ($cm^3$)** | 20.10 | 20.20 | 20.60 |

What can Layla do to improve the quality of her results?

........................................................................................................................

........................................................................................................................ **[1]**

'More repeats' was an easy and popular response to this final question. Some gave higher level answers about improving the fine detail of the techniques, for example by adding the acid dropwise near the end point.

## Copyright information

## Supporting you

For further details of this qualification please visit the subject webpage.

### Review of results

If any of your students' results are not as expected, you may wish to consider one of our review of results services. For full information about the options available visit the OCR website. If university places are at stake you may wish to consider priority service 2 reviews of marking which have an earlier deadline to ensure your reviews are processed in time for university applications.

## activeresults

***Review students' exam performance with our free online results analysis tool. Available for GCSE, A Level and Cambridge Nationals.***

It allows you to:

- review and run analysis reports on exam performance
- analyse results at question and/or topic level*
- compare your centre with OCR national averages
- identify trends across the centre
- facilitate effective planning and delivery of courses
- identify areas of the curriculum where students excel or struggle
- help pinpoint strengths and weaknesses of students and teaching departments.

*To find out which reports are available for a specific subject, please visit ocr.org.uk/administration/support-and-tools/active-results/

Find out more at ocr.org.uk/activeresults

## CPD Training

Attend one of our popular CPD courses to hear exam feedback directly from a senior assessor or drop in to an online Q&A session.

Please find details for all our courses on the relevant subject page on our website.

www.ocr.org.uk

# The small print

**OCR Resources:** *the small print*

OCR's resources are provided to support the delivery of OCR qualifications, but in no way constitute an endorsed teaching method that is required by OCR. Whilst every effort is made to ensure the accuracy of the content, OCR cannot be held responsible for any errors or omissions within these resources. We update our resources on a regular basis, so please check the OCR website to ensure you have the most up to date version.

This resource may be freely copied and distributed, as long as the OCR logo and this small print remain intact and OCR is acknowledged as the originator of this work.

Our documents are updated over time. Whilst every effort is made to check all documents, there may be contradictions between published support and the specification, therefore please use the information on the latest specification at all times. Where changes are made to specifications these will be indicated within the document, there will be a new version number indicated, and a summary of the changes. If you do notice a discrepancy between the specification and a resource please contact us at: resources.feedback@ocr.org.uk.

Whether you already offer OCR qualifications, are new to OCR, or are considering switching from your current provider/awarding organisation, you can request more information by completing the Expression of Interest form which can be found here: www.ocr.org.uk/expression-of-interest

Please get in touch if you want to discuss the accessibility of resources we offer to support delivery of our qualifications: resources.feedback@ocr.org.uk

## Looking for a resource?

There is now a quick and easy search tool to help find **free** resources for your qualification:

www.ocr.org.uk/i-want-to/find-resources/


**www.ocr.org.uk**

## OCR Customer Support Centre

**General qualifications**

Telephone 01223 553998
Facsimile 01223 552627
Email general.qualifications@ocr.org.uk




Cambridge Assessment

CERTIFIED ISO 9001 UKAS MANAGEMENT SYSTEMS 001