Qualification Accredited

Oxford Cambridge and RSA

GCSE (9-1)

Examiners' report

GATEWAY SCIENCE CHEMISTRY A

J248

For first teaching in 2016

J248/04 Summer 2018 series

Version 1

Contents

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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.

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Paper J248/04 series overview

J248/04 is the second of two examination components for candidates entered for the Higher Tier of the new revised GCSE examination for Gateway Science Chemistry A. This component 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.

Candidate performance

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

- Translated information between numerical and graphical form and vice versa: 17(a) & (b)(i) and 20(c)(i) & (ii).
- Constructed and balanced symbol equations for familiar and unfamiliar reactions: 18(a).
- Performed standard calculations following the required rubric (e.g. clear working, components and, where needed, significant figures) relating to titrations: 20(d)(ii), concentration of solutions: 21(a)(ii), moles and gas volumes: 21(b)(i) & (ii), and atom economy: 21(c)(i).
- Produced a clear, concise and well-structured answer for the Level of Response question: 19.
- Applied knowledge and understanding to questions set in a novel context.

Candidates who found this paper difficult generally did the following:

- Found it difficult to apply what they had learnt to unfamiliar situations.
- Found it difficult to analyse data and then make a judgement, or draw a conclusion, in relation to the data, e.g. 16(a) & (d).
- Found it difficult to analyse information to describe improvements to a specific experimental procedure, including stating and explaining safety precautions, e.g. 20(a), 22(f)(ii). Lower ability candidates often simply suggested repeating an experiment.
- Showed imprecise use of scientific terminology, e.g. 16(b), 18(c), 19, 21(c)(ii).

There was no evidence that time constraints had led to underperforming. Very few questions were left blank by candidates.

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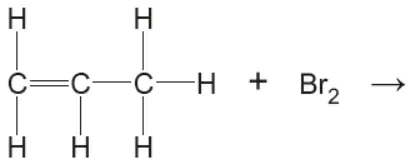
Section A overview

It would be worth centres stressing to candidates the importance of writing their answers to multiple choice questions clearly as some examiners reported difficulty in distinguishing, in particular, between 'B' and 'D' on scripts, especially when candidates had changed their answer.

Question 4

4 What is the formula of the product in this equation?



A C_2H_3Br

B $C_3H_5Br_2$

C C_2H_3Br

D $C_3H_6Br_2$

Your answer ☐ **[1]**

Two of the distractors in this MCQ were identical. However, this did not affect candidates' ability to select the correct answer.

Question 7

7 Look at the equation for a reversible reaction.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \quad \Delta H = -950\,kJ\,mol^{-1}$$

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

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

A Decreasing the pressure and decreasing the temperature.

B Increasing the pressure and decreasing the temperature.

C Increasing the pressure and increasing the temperature.

D Increasing the pressure and using a catalyst.

Your answer ☐ **[1]**

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This question required candidates to apply their knowledge of Le Chatelier's principle and assessed AO2. B was a common misconception as many candidates seemed to think that increasing the pressure in a reversible reaction will always favour the forward reaction.

Key:

Misconception

Question 11

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

A 20 cm^3

B 200 cm^3

C 500 cm^3

D 600 cm^3

Your answer ☐ **[1]**

B was a common misconception, with candidates doubling 100cm^3 as the concentration was doubled.

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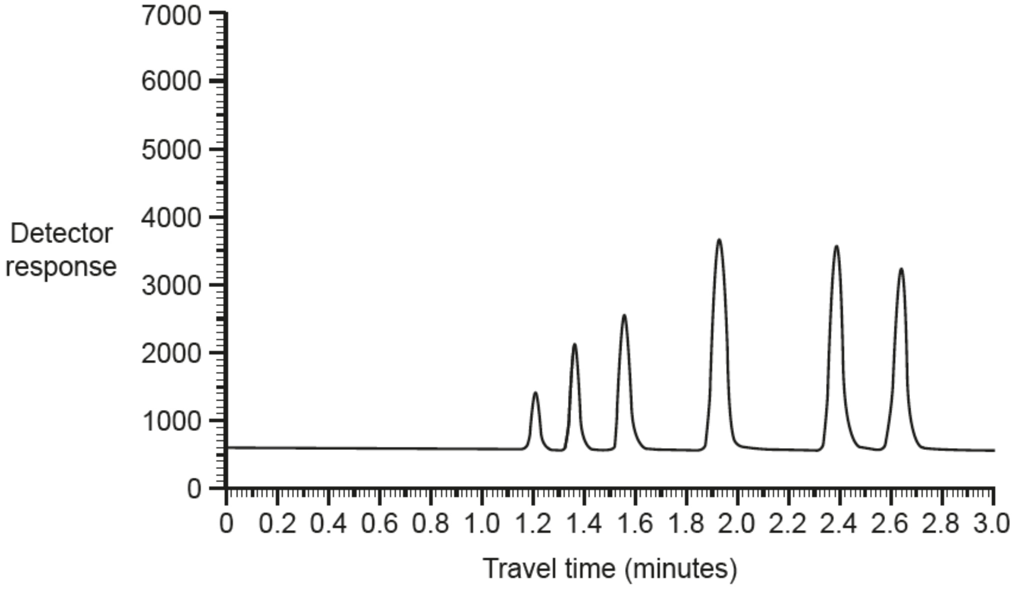
Question 14

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



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

A A gas chromatogram can detect very small amounts of substances.

B One compound produces several peaks.

C The area of each peak shows the relative amount of each substance.

D The retention time is different for different substances.

Your answer [ ] **[1]**

B was a common misconception.

Section B overview

Question 16 (a)

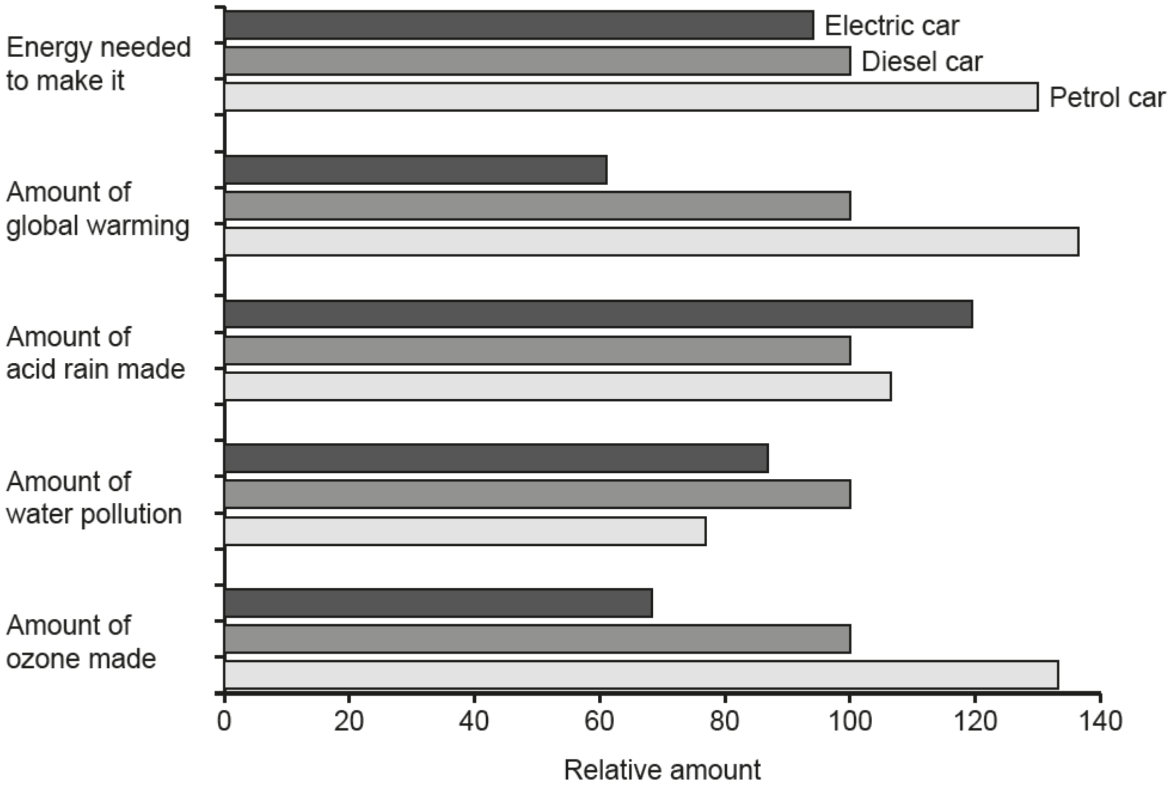
16 This question is about life-cycle assessment.

(a) A car company is developing three new cars:

- A petrol car
- A diesel car
- An electric car.

They do a life-cycle assessment of each car.

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



The company decides to manufacture and sell the electric car.

Explain why they make this choice.

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

....

....

....

.... **[3]**

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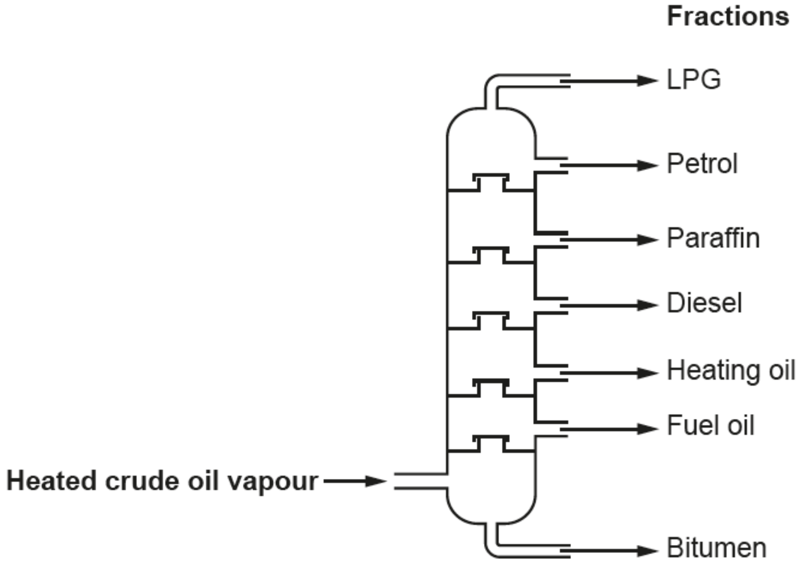
This question required candidates to use the life-cycle assessment data to compare the electric car to the petrol and diesel cars. Candidates who did not gain full credit often gave responses that were not comparative, stating only, for example, that the amount of ozone made by the electric car was low. Other candidates lost marks because they made global statements, e.g. 'the electric car is better in 3 categories' rather than using the three marks as a guide that three separate statements were required from the data. Vague generalisations about electric cars being 'more environmentally friendly' did not gain credit.

Question 16 (b)

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

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

The diagram shows a fractionating column.



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

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....

.... **[3]**

Good responses to this question appreciated that hydrocarbons have different boiling points and explained that larger molecules have stronger intermolecular forces, and hence higher boiling points. Lower ability candidates usually gained one or two marks for the idea of fractions having different boiling points and/or the fact that there is a temperature gradient within the fractionating column. Their answers needed to then *explain* how fractional distillation works. A common misconception was that crude oil was one of the fractions.

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Question 16 (d)

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

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

Feature	**Electric**	**Fuel cell**
Refuelling time (minutes)	360	4
Cost of refuelling (£)	3.20	4.20
CO_2 emitted (kg)	48	36
Mass of car (kg)	1550	1200

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

....

....

....

....

.... **[3]**

Similarly to 16(a), this question required candidates to use the data to *compare* the electric car to the car using a fuel cell. Again, candidates who did not gain full credit often gave responses that were not comparative, stating only, for example, that the car using a fuel cell emitted 36 kg of CO_2. Lower ability candidates interpreted the refuelling time as the time the car would run before needing to be refuelled.

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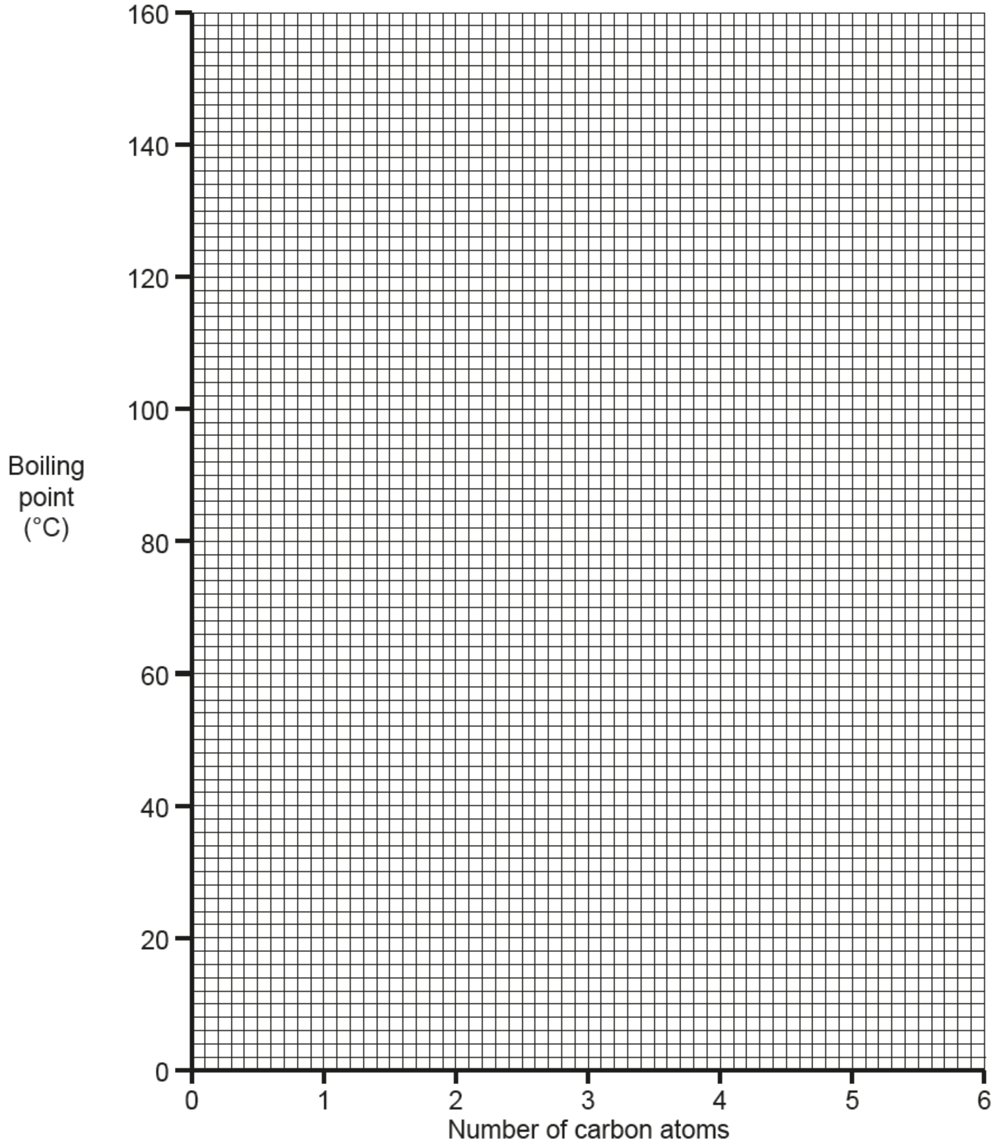
Question 17 (a)

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

Name	Number of carbon atoms	Boiling point (°C)
Methanol	1	65
Ethanol	2	79
Propanol	3	97
Pentanol	5	138
Hexanol	6	156

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



[3]

Many candidates gained full marks for this question; two marks were credited for plotting all the points correctly (± ½ square) and one mark for a correctly drawn line of best fit. It would be worth centres stressing to candidates the importance of using a pencil, rather than ink, in graphical questions. Candidates who tried to change points they had incorrectly plotted in ink often did not gain credit as it was not clear to the examiner where they had actually plotted their point. Plotting the points for pentanol and hexanol at 4 and 5 carbon atoms respectively on the x-axis was a common error.

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Question 17 (b) (i)

(b) **(i)** The student could not find a value for the boiling point of butanol, C_4H_9OH.

Use the graph to estimate the boiling point of butanol.

Answer = ... °C **[1]**

Examiners allowed answers to within ± 2°C of the candidate's graph, which allowed ECF from incorrectly plotting or line of best fit in part (a).

Question 17 (b) (ii)

(ii) Draw the **displayed formula** of butanol, C_4H_9OH.

[1]

Common misconceptions were to show C – H – O or to include a double bond, typically C=C or O=H.

Some lower ability candidates did not score the mark due to the omission of either the bonds between carbon atoms or the bonds between carbon and hydrogen atoms.

Question 17 (c)

(c) The alcohols all react in a similar way because they all contain the same **functional group**.

What is the functional group in an **alcohol** molecule?

.... **[1]**

A common error was OH^-.

Some lower ability candidates correctly wrote OH, but then contradicted their answer by also writing 'hydroxide'.

Question 17 (d)

(d) Ethanol, C_2H_5OH, can be oxidised to **ethanoic acid** using potassium manganate(VII).

What is the formula of ethanoic acid?

.... **[1]**

Carboxylic acids were not well known by candidates with examiners seeing a wide range of incorrect formulae. Some candidates attempted to write the dichromate equation for alcohol oxidation.

Propanoic acid, C_2H_5COOH, was a very common error.

Question 18 (a)

18 A student investigates the reaction between marble chips, $CaCO_3$, and hydrochloric acid.

Calcium chloride, $CaCl_2$, carbon dioxide and water are made.

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

.... **[2]**

Many candidates were able to write the correct balanced symbol equation for the reaction of marble chips with hydrochloric acid. One mark was credited for the correct reactants and products and one mark for the correct balancing. The balancing mark was dependent on the correct formulae, but one mark was allowed for a balanced equation with minor errors in subscripts or formulae (for example, $CaCO_3$ + 2HCL $\rightarrow$ $CaCl_2$ + CO2 +H_2O would gain one mark). When candidates did not gain marks, it was often because they wrote the formula for calcium chloride as $CaCl$, rather than using the correct formula given in the question.

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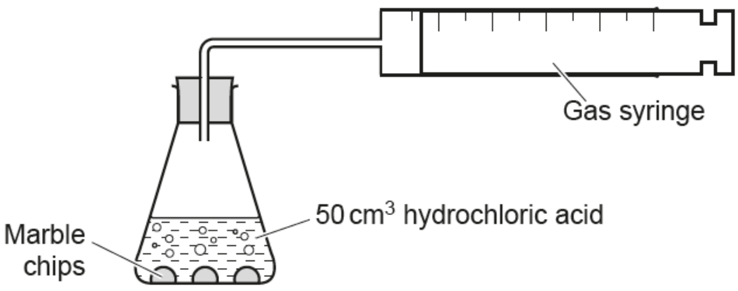
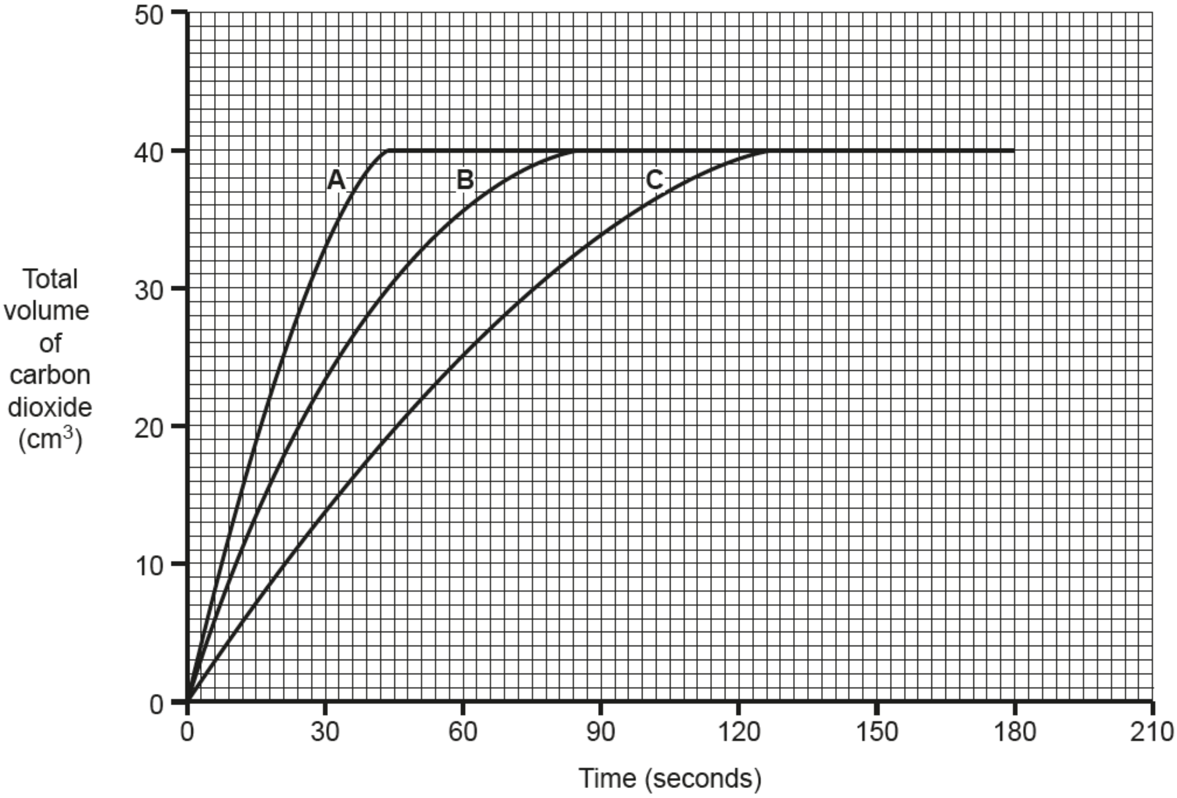
Question 18 (b)

(b) The student does three experiments, **A**, **B** and **C**.



In each experiment she uses a different size of marble chip. She uses the same mass of marble in each experiment. She also uses the same concentration of acid.

Look at the graph of her results.



Question 18 (b) (ii)

(ii) Look at the line for experiment **C**.

Calculate the **rate of reaction** during the first 45 seconds.

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

Answer = ... cm^3/s **[3]**

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Common errors in this question were:

- using a time other than 45 seconds
- 45 ÷ 20, rather than 20 ÷ 45
- giving an answer of 0.4, or 0.4 with a 'recurring dot', which examiners did not give credit for when awarding the significant figures mark.

It is worth centres stressing to candidates that if they are asked to give their answer to a specific number of significant figures, they can only score full marks by doing so.

Question 18 (c)

(c) The rate of reaction between marble and hydrochloric acid can be decreased by:

- Using a more dilute solution of hydrochloric acid
- Cooling the acid.

Explain how each of these methods make the reaction slower.

Use ideas about collisions between particles.

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.... **[4]**

Good responses to this question described that a more dilute solution would contain less crowded particles, and this would result in a reduced collision frequency. Candidates went on to describe that cooling the acid would result in the particles having less energy and therefore there would be a reduced frequency of successful collisions.

When candidates did not gain full credit, it was usually because they gave responses which were not sufficiently precise, e.g. 'in dilute acid particles are less concentrated', or simply referred to 'fewer collisions' rather than collision frequency / collisions per second.

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Exemplar 1

Use ideas about collisions between particles.

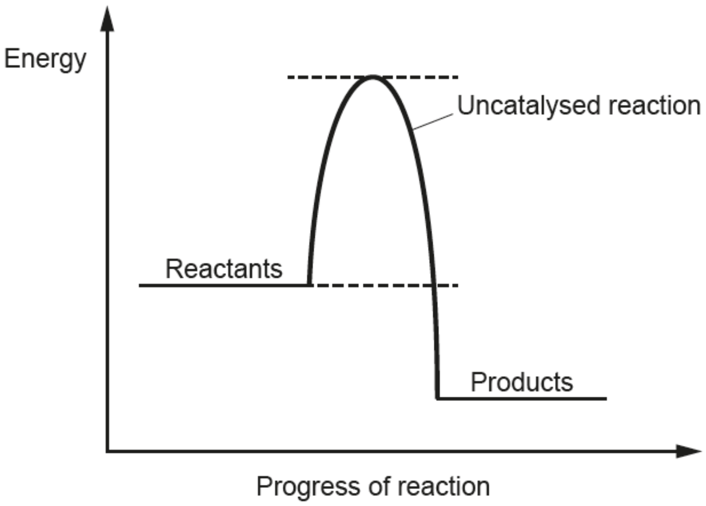
If the acid is cooled, the particles don't have as much kinetic energy to move, therefore there will be less successful frequent collisions between to hydrochloric acid particles and the marble ~~chips~~, therefore decreasing the rate of reaction. If the solution is more dilute, it has a weaker concentration. Therefore there are less particles in the volume of the solution which also means that there will be less successful frequent collisions between the acid particles and the marble. **[4]**

This response illustrates a high-quality answer, which addresses all aspects of the mark scheme. When explaining the effect of cooling the acid the candidate realises that the particles have less energy and appreciates that this will result in a lower collision frequency of successful collisions. Their answer explains that a lower concentration of acid means fewer particles in the same volume, which results in less frequent collisions. Examiners ignored references to 'successful' collisions in relation to diluting the acid.

Question 18 (d) (i)

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

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



Complete the energy profile diagram to show

(i) The reaction profile for the reaction with a catalyst. **[1]**

The reaction profile for the reaction with a catalyst was usually correctly shown.

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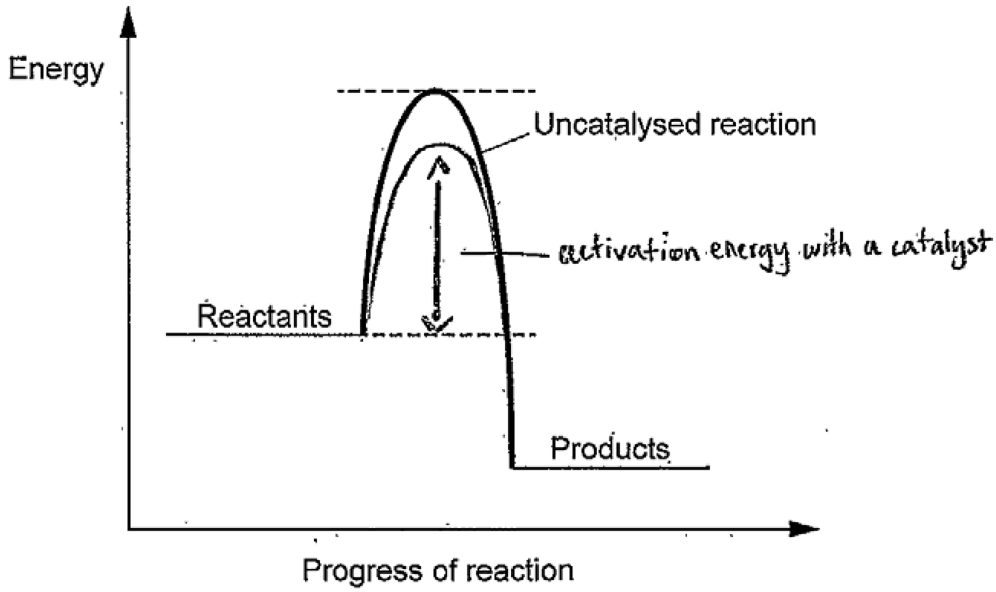
Question 18 (d) (ii)

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

Candidates who did not gain this mark usually indicated the activation energy with either a double headed arrow or a line without any arrow. As on J248/03, this did not gain credit.

Exemplar 2



This response illustrates a common error made by candidates, with a double headed arrow used to indicate the activation energy. The candidate's answer illustrates the comment that examiners only gave credit for correctly drawn single headed arrows, as is the correct convention for reaction profile diagrams.

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Question 19

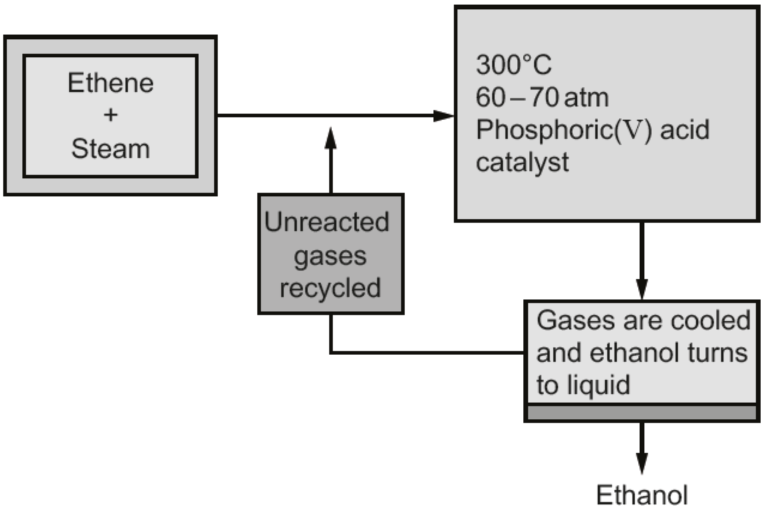
19* Ethanol is manufactured by reacting ethene, C_2H_4, with steam.

The reaction is reversible and occurs in a closed system.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45\,kJ\,mol^{-1}$$

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

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



Explain why the conditions used for the process are chosen.

....

....

....

.... **[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 draw conclusions about the conditions used for the process, applying their knowledge of Le Chatelier's principle correctly. Examiners saw some excellent responses, with candidates providing detailed explanations about why the conditions used in the process are chosen. Lower ability candidates usually gave responses in terms of only rate of reaction but were able to gain credit at Level 1. Vague comments about costs or profitability did not gain any credit.

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Exemplar 3

L3

Exothermic reactions (such as the forward reaction) work best at lower temperatures but too low the rate of reaction would be too slow so 300 °C is a compromise that allows for an equilibrium position towards the right with a decent rate of reaction. Having a higher pressure pushes the reaction in the direction of the side with least ~~molecules~~ mole which is the forward reaction so a fairly high pressure (without being expensive to run) ~~is~~ of 60-70 atm is a good one to use. The use of a catalyst doesn't ~~make~~ change the equilibrium position but does increase the rate of reaction. Removing the ethanol after each pass makes the reaction favour the forward reaction again since the reaction ~~then~~ has too many reactants and not enough products so it changes to make more products. These together are the best conditions that they could hope for in creating ethanol.

[6]

This is a Level 3, 6-mark response, which has analysed the information and applied knowledge of Le Chatelier's principle to explain the conditions used in the manufacture of ethanol. The candidate has clearly explained how 300°C and 60-70 atm are a compromise between rate of reaction and position of equilibrium. They appreciate that the phosphoric acid catalyst increases the rate without changing the position of equilibrium. Even without the final part of the answer, explaining the effect on the position of equilibrium of removing the ethanol, this response would have gained Level 3, 6 marks.

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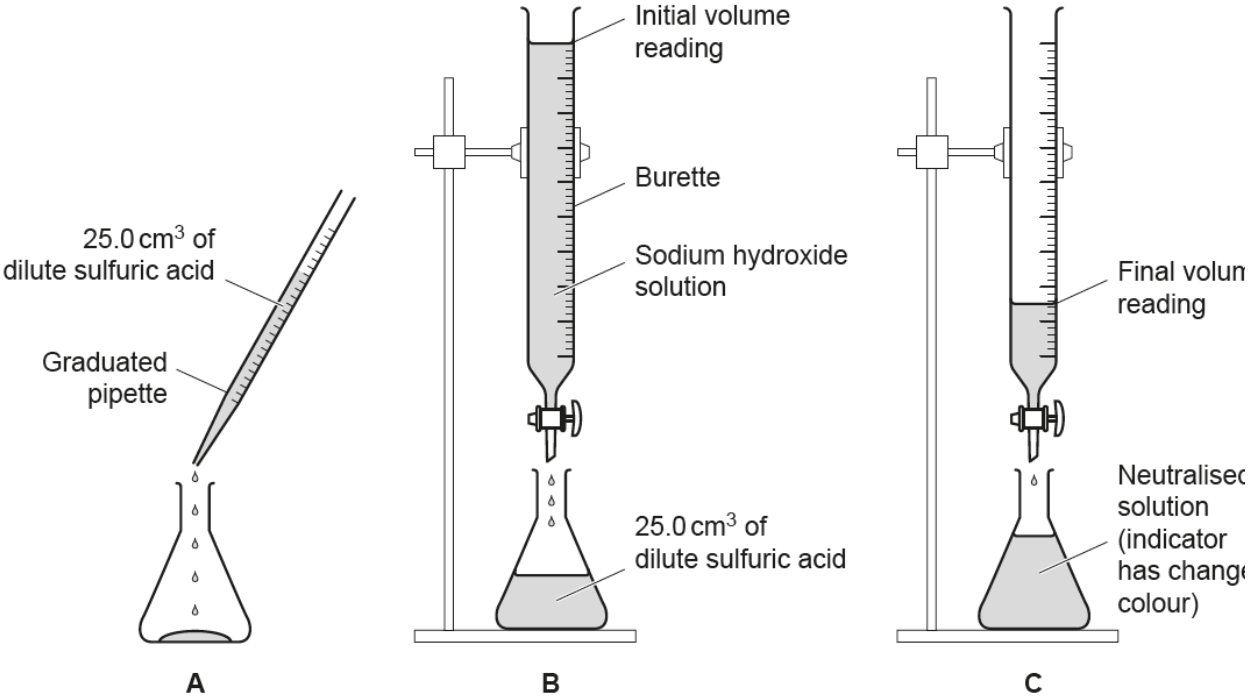
Question 20 (a)

20 Student **A** does a titration with an acid and an alkali.

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

The diagram shows the apparatus he uses.



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

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

He takes the final volume reading on the burette to find out how much acid reacts with 25.0 cm^3 of sodium hydroxide solution.

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

....

....

....

....

....

.... **[4]**

This question required candidates to describe how an experimental procedure could be improved and tested (AO3). The mark scheme allowed for a wide range of independent marking points, with only four from a possible twelve points being required. Higher ability candidates typically described adding the sodium hydroxide slowly as the indicator should change colour on addition of one drop. They often went on to suggest the use of a single indicator, e.g. methyl orange, rather than universal indicator. The idea of swirling the conical flask during the addition of the sodium hydroxide to ensure mixing of the acid and alkali was also frequently seen. Candidates who were credited with full marks obviously had first-hand experience of carrying out a titration.

Lower ability candidates gave answers relating to repeating the experiment, rather than actually improving the procedure. The use of a pH probe (the focus of part (b)) was also frequently discussed and did not gain credit.

We have adjusted the mark scheme to allow for a minor issue with this question. The question states that 'he takes the final volume reading on the burette to find out how much acid reacts with 25.0 cm^3 of sodium hydroxide solution'. It should have read 'he takes the final volume reading on the burette to find out how much alkali reacts with 25 cm^3 of dilute sulfuric acid'.

Question 20 (d) (ii)

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

$HCl + NaOH \rightarrow NaCl + H_2O$

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

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

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

Answer = ... mol/dm^3 **[4]**

Some of the responses were excellent, with clearly shown working out that was easy for the examiner to follow. If candidates did not obtain an answer of 0.25 mol/dm^3 examiners looked to award marks for working out and/or error carried forward. It is worth centres stressing to candidates that this is only possible when an answer is clearly set out.

Candidates usually correctly calculated the average titre of 25.05 cm^3. However, lower ability candidates then used the formula mass of either sodium hydroxide or hydrochloric acid to calculate the moles, and hence concentrations of the alkali and then acid.

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Exemplar 4

NaOH: Average titre = (25.1 + 25) ÷ 2 = 25.05 ÷ 1000 = 0.02505 dm^3

concentration = moles ÷ volume

NaOH: moles = 0.02505 × 0.2 = 0.00501

Answer = 0.25 mol/dm^3 **[4]**

HCl moles = 0.00501

concentration = $\frac{0.00501}{0.02}$ = 0.2505 mol/dm^3

HCl = 0.02 dm^3 0.00501 moles

NaOH = 0.2 mol/dm^3 0.02505 dm^3 0.00501 moles

This response illustrates a clearly laid out calculation, from which it was easy for the examiner to award all four marks. Many calculations were jumbled, however, and did not state what was being worked out (e.g. moles of NaOH or moles of HCl) at each stage. Although examiners credited 4 marks if the answer on the answer line was '0.25', if the answer was incorrect it became very difficult to look to credit marks for error carried forward from calculations which were not clearly set out. Centres are advised to stress to candidates the importance of showing all their working out clearly.

Question 21 (a) (i)

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

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

Answer = ... dm^3 **[1]**

?

Multiplying, rather than dividing, by 1000 to convert cm^3 to dm^3 was a common misconception.

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Question 21 (a) (ii)

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

Answer = ... g / dm^3 **[1]**

Examiners allowed error carried forward from part (a)(i).

Question 21 (b) (i)

(b) Zinc reacts with sulfuric acid. Zinc sulfate and hydrogen gas, H_2, are made.

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$$

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

Answer = ... mol **[2]**

?

Many candidates correctly calculated the moles of zinc as 3.27 ÷ 65.4 = 0.05, although 65.4 ÷ 3.27 was a common error.

Lower ability candidates then multiplied their answer of 0.05 by 2, to give an answer of 0.1 moles.

Question 21 (b) (ii)

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

One mole of any gas occupies 24 dm^3 at room temperature and pressure.

Answer = ... dm^3 **[2]**

Examiners allowed error carried forward from part (b)(i).

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Question 21 (c) (i)

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

$CH_4 + H_2O \rightarrow CO + 3H_2$

The **atom economy** for this process is 17.6%.

Hydrogen can also be produced by the decomposition of ammonia.

This reaction requires a catalyst.

$2NH_3 \rightarrow N_2 + 3H_2$

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

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

Answer = ... % **[3]**

?

Examiners saw many variations on incorrect calculations, which often only scored one mark for stating a number to 3 significant figures. However, the most frequent misconception was 6 ÷ 28 x 100%, i.e. mass of hydrogen ÷ mass of nitrogen x 100%.

Question 21 (c) (ii)

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

....

....

....

.... **[3]**

Higher ability candidates were able to suggest three, or often more, factors that must be considered when choosing a reaction pathway.

Lower ability candidates often just referred to 'cost' or 'cost of equipment' and did not gain credit. Examiners also did not give credit for vague response such as 'harming the environment' or 'safety'.

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Question 22 (b)

(b) Butene is an alkene.

What is the **general formula** for an alkene?

.... **[1]**

C_nH_{2n+2}, the general formula for an alkane, was a common misconception.

A common error was separating the C_n and the H_{2n} with a + sign, ie $Cn+H_{2n}$.

Question 22 (c)

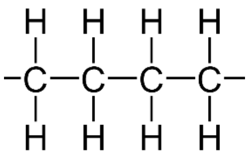
(c) Butene undergoes **addition polymerisation** to form poly(butene).

Write the **displayed formulae**, for poly(butene).

[2]

Many candidates drew the correct formula for the polymer, including the use of brackets and 'n'.

Common errors included the use of C=C, not showing the free 'end' bonds, or the polymer structure drawn as



Question 22 (d)

(d) DNA molecules are polymers made from four different monomers.

What are the monomers in DNA called?

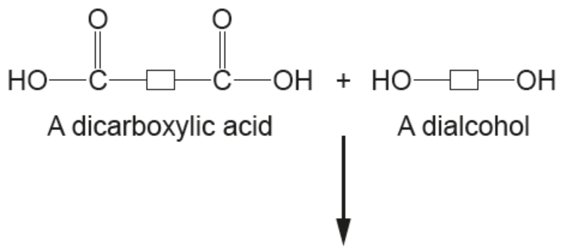
.... **[1]**

Common errors were 'bases', 'amino acids' or to name the bases, i.e. adenine, thymine, cytosine & guanine / ATCG.

Question 22 (e) (ii)

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

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



[2]

Examiners credited one mark for the correct ester linkage, and a second mark for correctly drawing the rest of the structure.

Common errors, resulting in the second mark not being credited, were the ends of the structure being 'closed' or both ends having a linking oxygen atom. Examiners also saw impossible structures that featured, for example, bridging groups, carbon atoms double bonded to OH groups or carbon atoms showing a valency of five.

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Question 22 (f) (i)

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

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

Both chemicals are highly corrosive.

A solvent is needed which is highly flammable.

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

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....

.... **[3]**

Good responses to this question described the idea of pouring one solution on top of the other solution to minimise mixing. They then described picking up the film of nylon at the interface of the layers with tweezers and lifting and drawing out the nylon slowly from the beaker.

Lower ability candidates tended to give conditions such as 'high temperature, high pressure and a catalyst'.

Question 22 (f) (ii)

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

....

....

....

.... **[3]**

Many candidates correctly used the information in the stem of the question to describe and explain the safety precautions required in this experiment. Lower ability candidates often did not gain full credit as they did not explain the precaution, e.g. stating 'wear goggles' without linking their answer to the highly corrosive nature of the chemicals.

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