CAMBRIDGE
International Examinations

Cambridge
IGCSE

Example Candidate Responses
(Standards Booklet)

Cambridge IGCSE®
Chemistry
0620

Cambridge Secondary 2

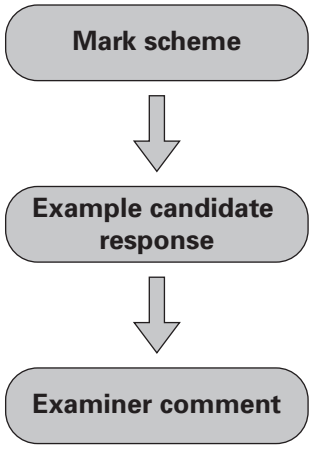
Contents

Introduction

The main aim of this booklet is to exemplify standards for those teaching Cambridge IGCSE Chemistry (0620), and to show how different levels of candidates' performance relate to the subject's curriculum and assessment objectives.

In this booklet a range of candidate responses has been chosen as far as possible to exemplify grades C and E for Paper 2 and grades A, C and E for Papers 3, 5 and 6. Each response is accompanied by a brief commentary explaining the strengths and weaknesses of the answers.

For ease of reference the following format for each paper has been adopted:



The mark scheme, used by examiners, is followed by examples of marked candidate responses, each with an examiner comment on performance. Comments are given to indicate where and why marks were awarded, and how additional marks could have been obtained. In this way, it is possible to understand what candidates have done to gain their marks and what they still have to do to improve their grades.

In this booklet a grade is given to each question but in the examination each question paper (whole candidate scipt) is graded on the overall mark awarded, not on each question or past question. It is therefore possible that, on some questions, lower grade candidate scripts were awarded the same or higher marks than higher grade candidate scripts.

Past papers, examiner reports and other teacher support materials are available on Teacher Support at http://teachers.cie.org.uk

Assessment at a glance

All candidates must enter for three papers.

<table>
<tr><th colspan="3">All candidates take:</th></tr>
<tr><td colspan="3">Paper 1 45 minutes
Multiple choice question paper
weighted at 30% of total available marks</td></tr>
<tr><th colspan="2">and either:</th><th>or:</th></tr>
<tr><td colspan="2">Paper 2 1 hour 15 minutes
Core theory paper
weighted at 50% of total available marks</td><td>Paper 3 1 hour 15 minutes
Extended theory paper
weighted at 50% of total available marks</td></tr>
<tr><th>and either:</th><th>or:</th><th>or:</th></tr>
<tr><td>Paper 4
Coursework
weighted at 20% of total available marks</td><td>Paper 5 1 hour 15 minutes
Practical Test
weighted at 20% of total available marks</td><td>Paper 6 1 hour
Alternative to Practical
weighted at 20% of total available marks</td></tr>
</table>

Teachers are reminded that a full syllabus is available at www.cie.org.uk

Paper 2 – Core theory

Paper 2 is a written, core theory paper consisting of short-answer and structured questions. Questions are based on the Core curriculum and will be of a difficulty appropriate to grades C to G. Candidates aiming for grades A* to C must follow the Extended curriculum. Questions will test skills mainly in assessment objectives A (Knowledge with understanding) and B (Handling information and problem solving).

Question 1

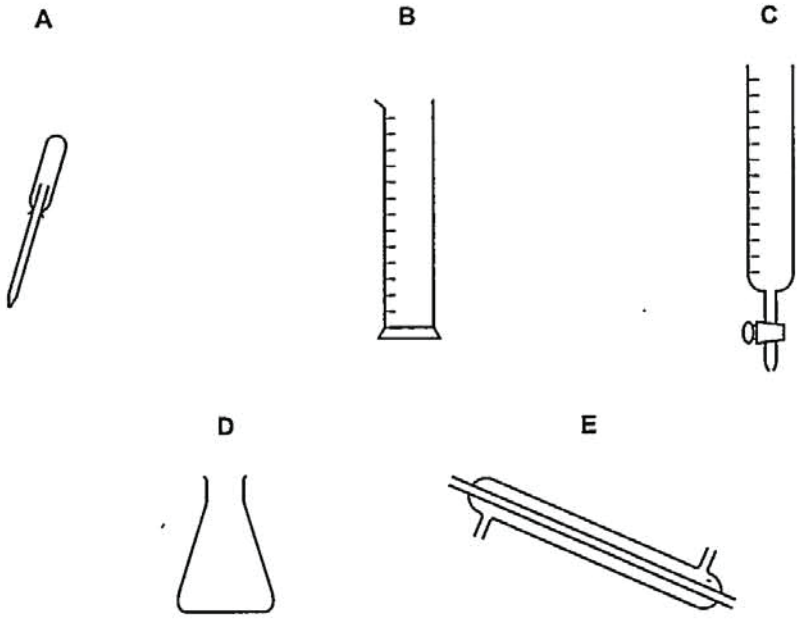
Mark scheme

1	**(a)**	**(i)**	C	[1]
		(ii)	A	[1]
		(iii)	E	[1]
		(iv)	D	[1]
		(v)	C	[1]
	(b)	**(i)**	limestone / chalk / marble **ignore:** lime / formulae	[1]
		(ii)	3rd box down ticked (heavier than air)	[1]
		(iii)	H_2O on right 2(HC*l*) second mark dependent on correct formula for water	[1] [1]

[Total: 9]

Example candidate response – grade C

1 The diagram shows five different pieces of laboratory glassware, **A**, **B**, **C**, **D** and **E**.



(a) Choose from **A**, **B**, **C**, **D** or **E** to answer the following questions.
Each letter may be used once, more than once or not at all.

Which piece of glassware is best used to

(i) measure out a volume of liquid accurately, B

(ii) place a spot of liquid on chromatography paper, A

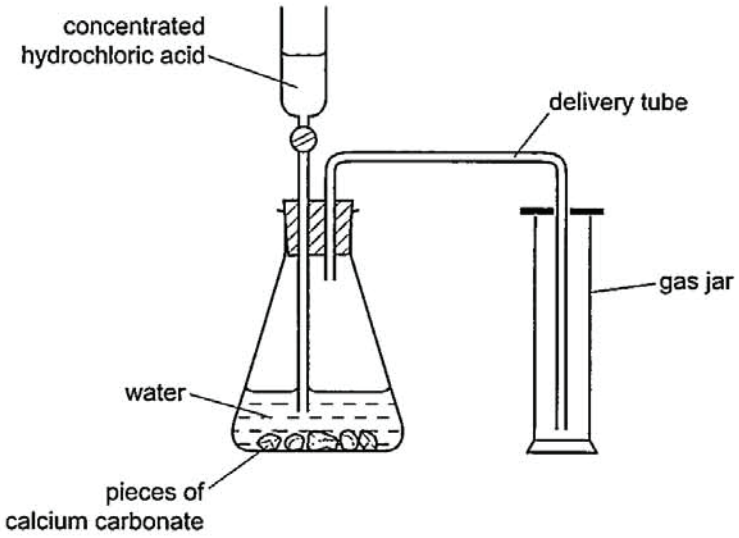
(iii) condense a liquid with a low boiling point, E

(iv) shake two solutions together to mix them, D

(v) deliver a variable volume of solution when performing a titration? C

[5]

(b) The diagram shows the apparatus used to prepare carbon dioxide in the laboratory.



(i) State the name of a rock which is made up largely of calcium carbonate.

Limestone ..... [1]

(ii) Which one of these statements about carbon dioxide is correct?
Tick **one** box.

Carbon dioxide is lighter than air.	✓
Carbon dioxide is a liquid at room temperature.	
Carbon dioxide is heavier than air.	
Carbon dioxide has the same density as air.	

[1]

(iii) Complete the equation for the reaction of calcium carbonate with hydrochloric acid.

$CaCO_3$ + ...2...$HCl \rightarrow CaCl_2 + CO_2 +$ ...H_2O... [2]

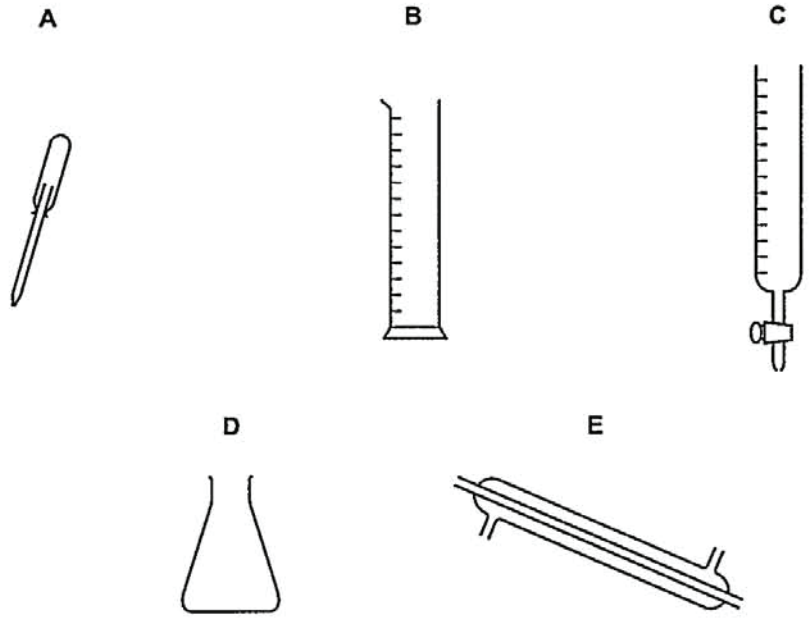
[Total: 9]

Examiner comment – grade C

This question was answered well and gained most of the marks available. In **(a)** the candidate was usually able to select the appropriate piece of glassware for a particular use whilst in **(b)(iii)** the candidate demonstrated a good ability in balancing the equation. In **(a)(i)** the mark could have been scored by a better understanding of the concept of accuracy. A burette is far more accurate than a measuring cylinder when measuring out exact quantities of a liquid. When questions are of an unfamiliar nature as in **(b)(ii)**, it is important to refer back to diagrams or other information in the stem of the question. For example, in **(b)(ii)**, the fact that carbon dioxide was collected by downward delivery suggests that it is heavier than air rather than lighter than air as suggested by the candidate.

Example candidate response – grade E

1 The diagram shows five different pieces of laboratory glassware, **A**, **B**, **C**, **D** and **E**.



(a) Choose from **A**, **B**, **C**, **D** or **E** to answer the following questions.
Each letter may be used once, more than once or not at all.

Which piece of glassware is best used to

(i) measure out a volume of liquid accurately, B

(ii) place a spot of liquid on chromatography paper, A

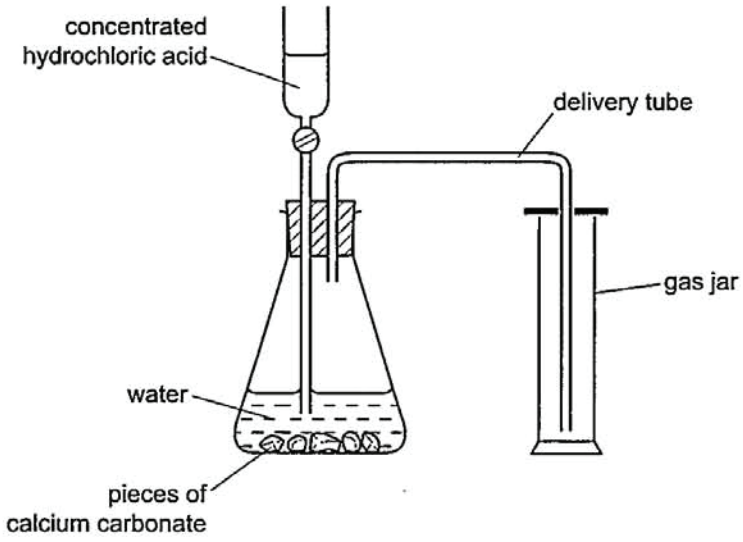
(iii) condense a liquid with a low boiling point, E

(iv) shake two solutions together to mix them, D

(v) deliver a variable volume of solution when performing a titration? C

[5]

(b) The diagram shows the apparatus used to prepare carbon dioxide in the laboratory.



(i) State the name of a rock which is made up largely of calcium carbonate.

limestone ..... [1]

(ii) Which one of these statements about carbon dioxide is correct?
Tick **one** box.

Carbon dioxide is lighter than air.	
Carbon dioxide is a liquid at room temperature.	
Carbon dioxide is heavier than air.	☒
Carbon dioxide has the same density as air.	

[1]

(iii) Complete the equation for the reaction of calcium carbonate with hydrochloric acid.

$CaCO_3$ + ...2...$HCl \rightarrow CaCl_2 + CO_2$ + ...H_2O... [2]

[Total: 9]

Examiner comment – grade E

The candidate tackled this question reasonably well. In **(a)** the candidate was usually able to select the appropriate piece of glassware for a particular use. In **(b)(iii)** no marks were scored because the candidate did not realise that water was the third product of the reaction. In **(a)(i)** the mark could have been scored by a better understanding of the concept of accuracy. A burette is far more accurate than a measuring cylinder when measuring out exact quantities of a liquid. When questions deal with unfamiliar reactions, it is often useful to refer back to diagrams or other information in the stem of the question. For example, in **(b)(ii)**, the fact that carbon dioxide was collected by downward delivery suggests that it is heavier than air rather than lighter than air as suggested by the candidate. In **(b)(iii)** no marks were scored because the incorrect product, hydrogen, was suggested. A mark could have been gained in this question if the correct product (water) had been written down. The second mark in this type of question is usually dependent on the correct product of the reaction being given. When writing the formulae of substances such as hydrogen, nitrogen and oxygen, candidates should remember that only the forms H_2, N_2 and O_2 are acceptable (rather than 2H, 2N and 2O).

Question 2

Mark scheme

2 (a) copper → any common use e.g. electrical wiring / pipes jewellery [1]
ignore: for alloys / for brass / for wires (unqualified)

platinum → any common use e.g. inert electrode / jewellery [1]
allow: for catalyst (as long as not incorrect catalyst)
aluminium → any common use e.g. food containers / car (bodies) / aircraft (bodies) / kitchen utensils / pots and pans [1]
allow: for roofing / for high voltage electrical cables
ignore: for wires / for knives

(b) (i) poisonous / harms nervous system or brain [1]
ignore: harmful (without qualification)

(ii) protons → 82 [1]
neutrons → 125 [1]

(c) (i) Any three of: [3]
sodium goes into a ball /
gets smaller / disappears
allow: dissolves **ignore:** reacts
moves (over surface)
bubbles / effervescence /
ignore: hydrogen given off
floats on the water (as it reacts) /
fizzes / hissing / crackling
ignore: sound
litmus turns blue /
ignore: changes colour

(ii) sodium hydroxide [1]
hydrogen [1]

(iii) electron [1]
Ion [1]
gains [1]
negative [1]

[Total: 15]

Example candidate response – grade C

2 Many of the elements in the Periodic Table are metals.

(a) State **one** common use for each of the following metals.

(i) copper Making Steel [1]

(ii) platinum Decoration, Ring, Jewerly [1]

(iii) aluminium Airplane body [1]

(b) Lead is a metal in Group IV of the Periodic Table.

(i) State **one** adverse effect of lead on health.

Cause cancer [1]

(ii) Lead has several isotopes.
One isotope of lead is

82

$^{207}_{82}Pb$ 125

State the number of protons and neutrons in this isotope of lead.

number of protons 82 [1]

number of neutrons 125 [1]

(c) Sodium is a very reactive metal.

(i) A student added a few drops of litmus solution to a large beaker of water. She then dropped a small piece of sodium into the beaker.
Describe what the student would observe during the reaction.

A violent reaction take place as Na contact with water. The product is NaOH which make the solution Alkali. litmus turn blue. [3]

(ii) Complete the word equation for the reaction of sodium with water.

sodium + water → Sodium Hydroxide + Hydrogen [2]

$2Na + 2H_2O \rightarrow 2NaOH + H_2$

(iii) Sodium chloride is formed when sodium burns in chlorine.
Sodium chloride is an ionic compound.
Complete the following sentences about this reaction using words from the list.

electron	**gains**	**ion**	**loses**
molecule	**negative**	**positive**	**proton**

When sodium burns in chlorine, each sodium atom loses an electron and becomes a sodium ion. Each chlorine atom gains an electron and becomes a negative ion, [4]

[Total: 15]

Examiner comment – grade C

This question was fairly well answered. The correct interpretation of the isotopic composition in **(b)(ii)** and a good knowledge of chemical reactions in **(c)(ii)** and **(c)(iii)** helped to gain good marks. In **(a)** the uses of platinum and aluminium were known but the use of copper in steel making was not given credit. It should be remembered that not all transition metals are added to iron to make useful steels. In **(b)(i)**, no mark was given – it should be remembered that not all chemicals cause cancer. Candidates should be advised to make a list of the uses and effects of the substances required by the syllabus but list no more than two uses / effects for each. Only one mark was gained for **(c)(i)** for litmus turns blue. To gain full marks, the candidate should write down observations rather than general statements, e.g. 'violent reaction' or naming products, e.g. sodium hydroxide'. In answering this sort of question, it is important to distinguish the meaning of the various key words listed in the appendix of the syllabus under 'Glossary of terms used in science papers'.

Example candidate response – grade E

2 Many of the elements in the Periodic Table are metals.

(a) State **one** common use for each of the following metals.

(i) copper :- wires ..... [1]

(ii) platinum :- Ornaments ..... [1]

(iii) aluminium :- in utensils ..... [1]

(b) Lead is a metal in Group IV of the Periodic Table.

(i) State **one** adverse effect of lead on health.

Can lead to asthama ..... [1]

(ii) Lead has several isotopes.
One isotope of lead is

$$^{207}_{82}Pb$$

State the number of protons and neutrons in this isotope of lead.

number of protons 82 ..... [1]

number of neutrons 125 ..... [1]

(c) Sodium is a very reactive metal.

(i) A student added a few drops of litmus solution to a large beaker of water. She then dropped a small piece of sodium into the beaker.
Describe what the student would observe during the reaction.

She could see the colour changing to red and the small piece getting disappeared. ..... [3]

(ii) Complete the word equation for the reaction of sodium with water.

sodium + water → Sodium oxide + Hydrogen ..... [2]

(iii) Sodium chloride is formed when sodium burns in chlorine.
Sodium chloride is an ionic compound.
Complete the following sentences about this reaction using words from the list.

electron	**gains**	**ion**	**loses**
molecule	**negative**	**positive**	**proton**

When sodium burns in chlorine, each sodium atom loses an electron and becomes a sodium ion. Each chlorine atom gain an electron and becomes a negative ion. [4]

[Total: 15]

Examiner comment – grade E

The correct interpretation of the isotopic composition in **(b)(ii)** and a knowledge of the nature of chemical reactions in **(c)(iii)** helped the candidate to gain 8 out of 15 marks for this section. More revision of specific uses of metals was required to improve the marks. In **(a)** the answers 'wires', 'ornaments' and 'utensils' were far too vague to gain credit. Electricity wires, jewellery and saucepans would have gained the marks. In **(b)(i)**, no mark was given – reference was needed to the poisonous nature of lead. Candidates should be advised to make a list of the uses and effects of the substances required by the syllabus but list no more than two uses / effects for each. In this way there is no 'overload' of extra material to be learnt. Only one mark was gained for **(c)(i)** for 'small piece getting disappeared'. The candidate knew the term observation refers to what is seen, heard or felt, but only one correct observation was given. There are three marks for the question, so three separate observations are required. In **(c)(ii)**, only one of the two marks was scored. The candidate knew that hydrogen was given off but did not realise that sodium hydroxide rather than sodium oxide is formed. Full marks were given to the answers in **(c)(iii)**.

Question 3

Mark scheme

3 (a) Any two of: [2]
temperature
mass / amount of manganese(IV) oxide / volume of manganese(IV) oxide
size of manganese dioxide particles
allow: pressure
ignore: concentration

(b) (i) the greater the concentration the greater the speed / rate increases with concentration [1]
ignore: concentration increases speed / more oxygen the grater the concentration

(ii) less hydrogen peroxide present (in B) / more hydrogen peroxide (in A) [1]
allow: hydrogen peroxide less concentrated (in B)

(iii) time taken → 27 (s) [1]
allow: 26 (s)
volume → 37 (cm^3) [1]

(c) magnesium → copper → manganese → lead [1]
ignore: oxide / oxidation numbers

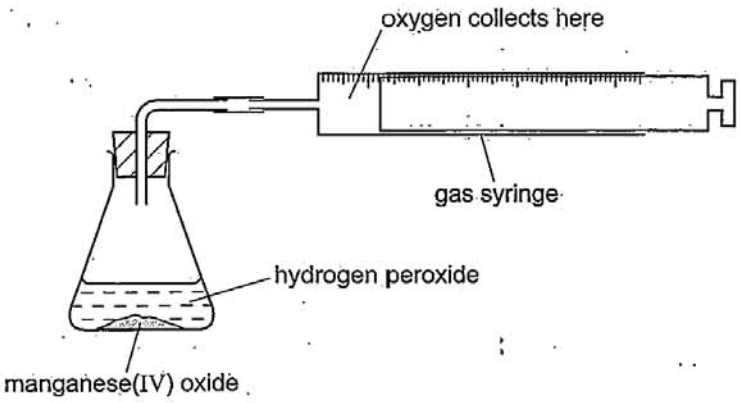
[Total: 7]

Example candidate response – grade C

3 Hydrogen peroxide decomposes slowly at room temperature to form water and oxygen. The reaction is catalysed by manganese(IV) oxide.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

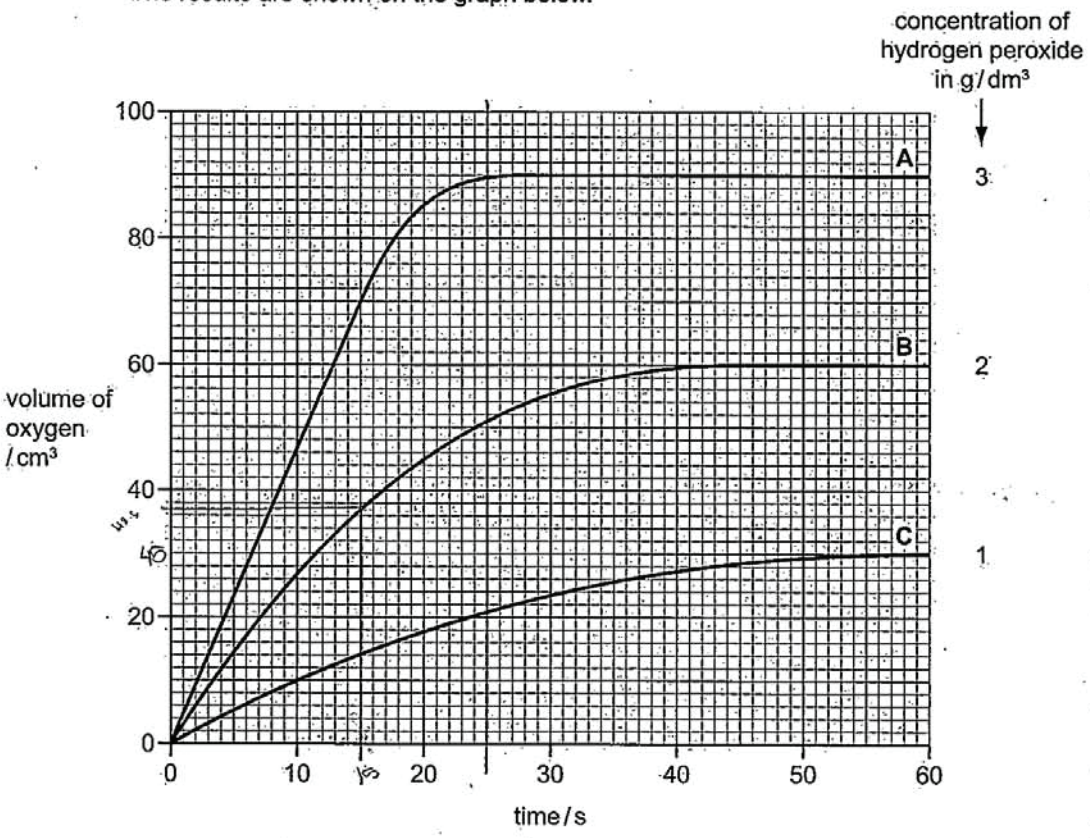
A student used the apparatus shown below to study how changing the concentration of hydrogen peroxide affects the speed of this reaction.



(a) Apart from the volume of hydrogen peroxide, state two things that the student must keep the same in each experiment.

1. The amount of manganese (IV) oxide used
2. The same (room temperature) for the whole experiment [2]

(b) The student measured the volume of oxygen produced using three different concentrations of hydrogen peroxide.
The results are shown on the graph below.



(i) Describe how the speed of the reaction varies with the concentration of hydrogen peroxide.

as there is an increase in the concentration, the speed of reaction also increases. [1]

(ii) Explain why the final volume of oxygen given off is less for graph **B** than for graph **A**.

As the reactions happened at took place at a slower rate due to the concentration for that they were less concentrated than A. [1]

(iii) From the graph, determine

the time taken for the reaction to be completed when 3 g / dm³ hydrogen peroxide (line **A**) was used.

25 seconds ..... [1]

the volume of oxygen produced by 2 g / dm³ hydrogen peroxide (line **B**) in the first 15 seconds.

48 ~~48.5~~ cm³ ..... [1]

(c) The student then tested various compounds to see how well they catalysed the reaction.
He used the same concentration of hydrogen peroxide in each experiment.
The table shows the time taken to produce 20 cm^3 of oxygen using each compound as a catalyst.

compound	time taken to produce 20 cm^3 of oxygen / s
copper(II) oxide	130
lead(IV) oxide ✓	15
magnesium oxide	did not produce any oxygen
manganese(IV) oxide	18

It is not a catalyst

Put these compounds in order of their effectiveness as catalysts.

worst catalyst ⟶ best catalyst

Magnesium Oxide | Lead(IV) oxide | Manganese (IV) oxide | Copper Oxide

[1]

[Total: 7]

Examiner comment – grade C

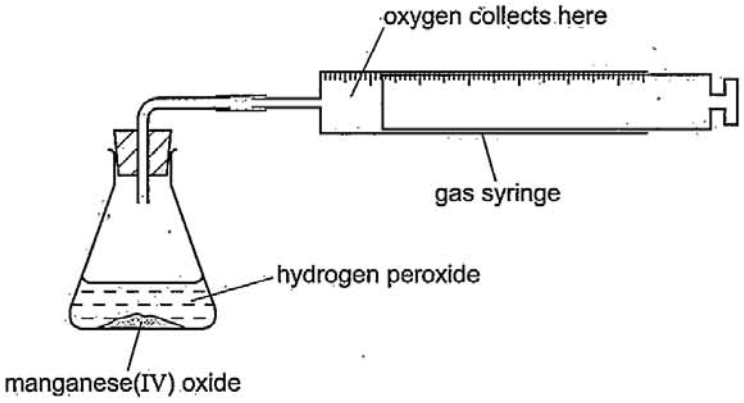
The answer shows that the candidate had a good general understanding of rates of reaction but more practice was needed in questions involving interpretation of data i.e. questions **(b)(iii)** and **(c)**. Suitable factors to be kept constant were given in **(a)**, and in **(b)(i)**, the candidate realised that an increase in concentration increases the rate. The answer to **(b)(ii)** was less convincing but 'less concentrated than A' was allowed on the mark scheme. A more convincing answer would refer to a greater amount of hydrogen peroxide. In order to improve the marks in **(b)(iii)** more practice of graph reading is needed. The time taken for the reaction to be completed should have been deduced to the nearest small square, rather than to the nearest major line, whilst in the second part the candidates used the 10 s rather than 15 s time interval. In **(c)**, rate was not interpreted correctly, the candidate using time synonymously with rate hence suggesting, incorrectly, that lead oxide (15 s) was slower than manganese oxide (18 s) and copper oxide (130 s) was the fastest. It is important that candidates realise that rate is inversely proportional to time.

Example candidate response – grade E

3 Hydrogen peroxide decomposes slowly at room temperature to form water and oxygen. The reaction is catalysed by manganese(IV) oxide.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

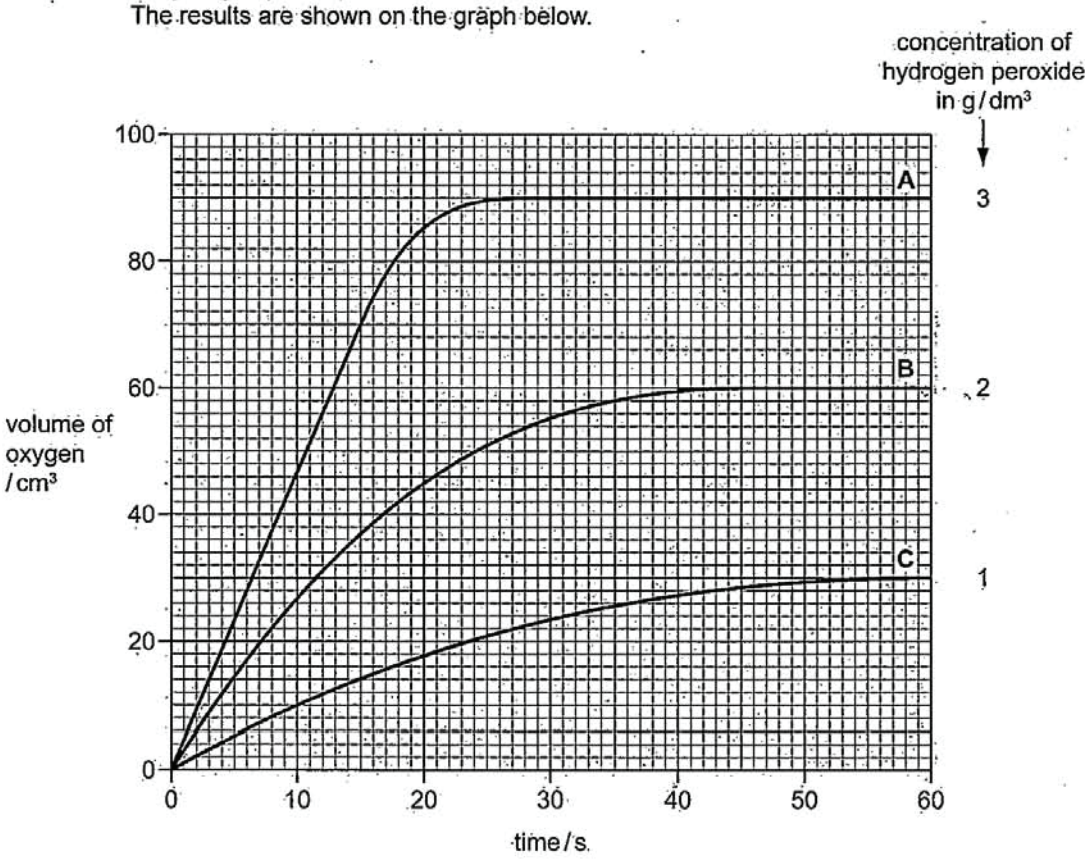
A student used the apparatus shown below to study how changing the concentration of hydrogen peroxide affects the speed of this reaction.



(a) Apart from the volume of hydrogen peroxide, state two things that the student must keep the same in each experiment.

1. The amount of oxygen collected in the syringe
2. The manganese [IV] oxide in the beaker [2]

(b) The student measured the volume of oxygen produced using three different concentrations of hydrogen peroxide.
The results are shown on the graph below.



(i) Describe how the speed of the reaction varies with the concentration of hydrogen peroxide.

It varies with it by the concentration and volume [1]

(ii) Explain why the final volume of oxygen given off is less for graph **B** than for graph **A**.

It is less because the concentration of hydrogen peroxide is less than that of graph A [1]

(iii) From the graph, determine

the time taken for the reaction to be completed when 3 g / dm³ hydrogen peroxide (line **A**) was used.

0sec [1]

the volume of oxygen produced by 2 g / dm³ hydrogen peroxide (line **B**) in the first 15 seconds.

60cm³ [1]

(c) The student then tested various compounds to see how well they catalysed the reaction. He used the same concentration of hydrogen peroxide in each experiment. The table shows the time taken to produce 20 cm^3 of oxygen using each compound as a catalyst.

compound	time taken to produce 20 cm^3 of oxygen / s
copper(II) oxide	130
lead(IV) oxide	15
magnesium oxide	did not produce any oxygen
manganese(IV) oxide	18

Put these compounds in order of their effectiveness as catalysts.

worst catalyst ⟶ best catalyst

Copper (II) oxide | Manganese (IV) oxide | Magnesium oxide | Lead oxide

[1]

[Total: 7]

Examiner comment – grade E

This answer shows that the general understanding of rates of reaction and experimental processes needs to be improved. More practice is also needed with questions involving interpretation of data, i.e. questions **(b)(iii)** and **(c)**. In **(a)**, no marks were given because the candidate focused on the product rather than writing about the factors to be kept constant in the experiment. The answer 'the manganese(IV) oxide in the beaker' was judged too vague to be given credit. 'The amount of manganese oxide' would have gained the mark. In **(b)(i)**, the mark was not gained because of vague writing. 'It varies…' is not sufficient because it is not clear whether the rate increased with increasing or decreasing concentration. The answer to **(b)(ii)** was not very convincing but 'concentration is less than that in graph A' was allowed on the mark scheme. A more convincing answer would refer to a greater amount of hydrogen peroxide. In order to improve the marks in **(b)(iii)** more practice in interpreting graphs was needed. The candidate focused on the first and last time points on the graph rather than considering the curves. In **(c)**, although some of the oxides were in the correct position, manganese was not.

Question 4

Mark scheme

4 (a) methane [1]

(b) arrangement → random / irregularly arranged / no fixed position [1]
proximity → close together / touching [1]
motion → random/ sliding over each other / movement not entirely free [1]
allow: move slightly

(c) (i) arrow at tube at bottom left [1]
ignore: direction of arrow

(ii)
group of (different) molecules / group of (different) hydrocarbons [1]
implication of different molecules
with similar / (particular) range of boiling points / molecules with similar molecular masses or small range of molecular masses [1]

(iii) X → naphtha [1]
Y → diesel (oil) [1]

(iv) structure of ethane showing all atoms and all bonds [1]

(v) 2nd box down ticked (saturated hydrocarbon) [1]

[Total: 11]

Example candidate response – grade C

4 Natural gas and the hydrocarbons obtained from the distillation of petroleum are important fuels.

(a) State the name of the main substance present in natural gas.

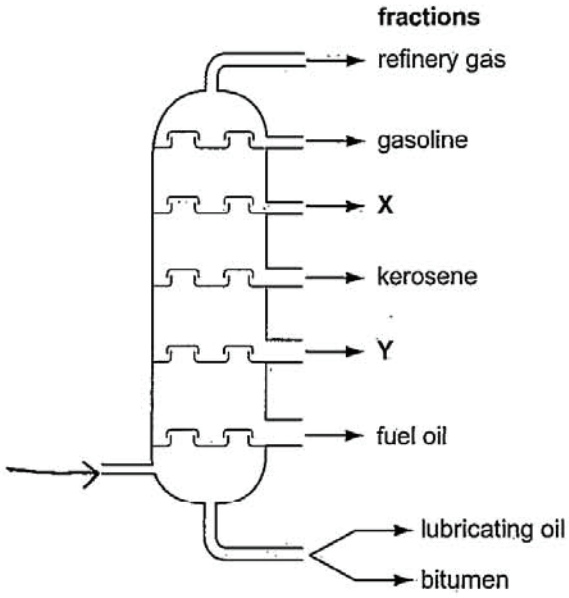
methane [1]

(b) Petroleum is a thick liquid.
Describe the liquid state in terms of

- how close the particles are to each other,
- the arrangement of the particles,
- the movement of the particles.

The particles are closely packed together with spaces in between. They are arranged irregularly in no particular order. The particles are free to move and slide over each other, though less so than those of thinner liquids. [3]

(c) The diagram shows a distillation column used to separate petroleum into fractions.



(i) On the diagram, draw an arrow to show where the petroleum vapour enters the column. [1]

(ii) What do you understand by the term *fraction*?

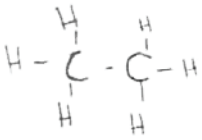
A fraction is an individual element which is part of a mixture. [2]

(iii) In the diagram on page 9, two fractions have not been named.
State the name of

fraction **X** ..... Petrol .....

fraction **Y** ..... Paraffin ..... [2]

(iv) One of the refinery gases is ethane.
Draw the structure of ethane showing all atoms and bonds.



[1]

(v) Which one of these phrases describes ethane correctly?
Tick **one** box.

Ethane is an unsaturated hydrocarbon.	☐
Ethane is a saturated hydrocarbon.	☑
Ethane polymerises to form poly(ethene).	☐
Ethane is an alkene.	☐

[1]

[Total: 11]

Examiner comment – grade C

This answer demonstrates a good understanding of the particulate nature of the liquid state. The basic organic chemistry (**(c)(iv)** and **(v)**) was good although the concept of what a fraction is and the nature of different fractions in oil distillation needed revision. In **(b)**, the candidate gave a good answer with three separate statements relating to the three marks available: 'closely packed', 'arranged irregularly' and 'slide over each other'. The inclusion of comparison with other liquids was not necessary. In **(c)(ii)**, the candidate showed some knowledge of the term 'fraction' by writing about 'elements as part of the mixture', but this was not sufficiently rigorous to gain a mark. In **(c)(iii)**, the candidate seemed not to realise that petrol was the same as gasoline and kerosene is the same as paraffin. In both these parts more straightforward learning was required.

Example candidate response – grade E

4 Natural gas and the hydrocarbons obtained from the distillation of petroleum are important fuels.

(a) State the name of the main substance present in natural gas.

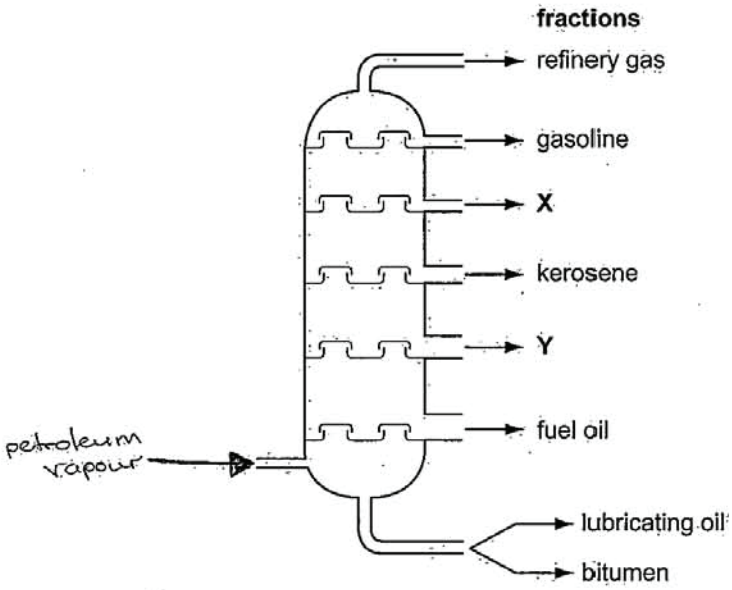
Nitrogen [1]

(b) Petroleum is a thick liquid.
Describe the liquid state in terms of

- how close the particles are to each other,
- the arrangement of the particles,
- the movement of the particles.

The particles are close together in a ball-stick arrangement. As it is a thick liquid, particles move about haphazardly, but the space between them is smaller compared to liquids like water. [3]

(c) The diagram shows a distillation column used to separate petroleum into fractions.



(i) On the diagram, draw an arrow to show where the petroleum vapour enters the column. [1]

(ii) What do you understand by the term *fraction*?

The division of substances into different parts either by half or even smaller segments. [2]

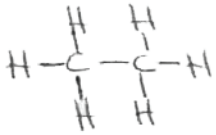
(iii) In the diagram on page 9, two fractions have not been named.
State the name of

fraction **X** Petrol

fraction **Y** Diesel [2]

(iv) One of the refinery gases is ethane.
Draw the structure of ethane showing all atoms and bonds.

C_2H_6



[1]

(v) Which one of these phrases describes ethane correctly?
Tick **one** box.

Ethane is an unsaturated hydrocarbon.	☐
Ethane is a saturated hydrocarbon.	☐
Ethane polymerises to form poly(ethene).	☑
Ethane is an alkene.	☐

[1]

[Total: 11]

Examiner comment – grade E

This answer shows some understanding of the particulate nature of the liquid state and a limited knowledge of organic chemistry. The concept of what a fraction is and the nature of different fractions in oil distillation needed revision. In **(a)**, the candidate may have interpreted natural gas as gas present in the air rather than gas from the ground. In **(b)**, the candidate gave a reasonable good answer although it was rather contradictory and vague in places. The marks were given for the 'particles close together' (ball and stick was ignored) and 'haphazardly'. The inclusion of comparison with other liquids was not necessary and reference to 'the space between them is smaller' enhanced the confusion. In **(c)(ii)**, the candidate showed some knowledge of the term 'fraction' by writing about 'the division of substances into different parts', but this was not sufficiently rigorous to gain a mark. In **(c)(iii)**, the candidate seemed not to realise that petrol was the same as gasoline but correctly identified the diesel fraction. In **(c)(iv)**, the structure of ethane was well drawn, but in **(c)(v)**, the chemical nature of ethane was not understood.

Question 5

Mark scheme

5 **(a)** molecule → two or more atoms [1]
atom → the smallest part [1]
ion → an atom that has become [1]

(b) **(i)** pH 13 [1]

(ii) 40 [1]

(iii) neutralisation [1]

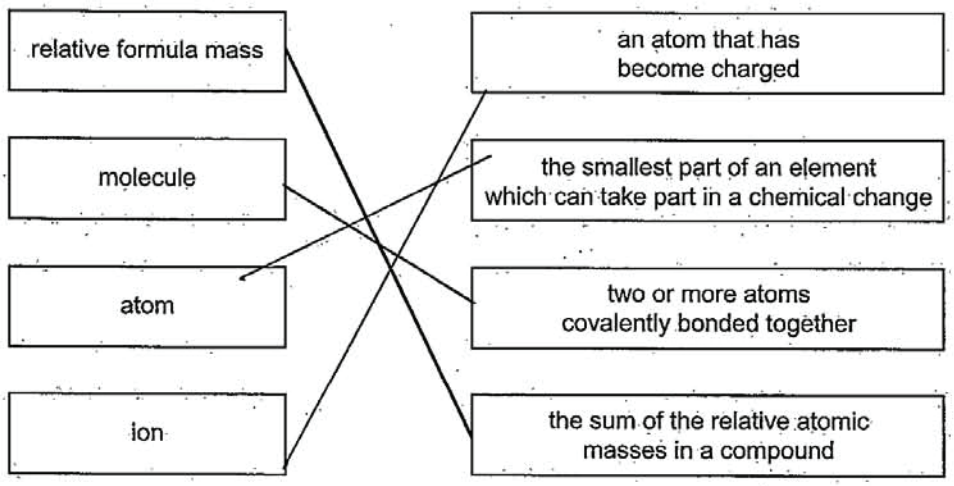
(iv) pH decreases / pH goes from higher to lower pH / suitable reference to pH values e.g. from pH 12 to pH 8 [1]
final pH below 7 / stated value below 7 [1]
ignore: gets more acidic

(c) Any six of: [6]
bubbles (from the electrodes)
solution goes yellow(ish) / solution goes green(ish)
hydrogen at cathode
chlorine at anode
(hydrogen and chlorine gases produced at wrong electrodes = 1)
electrodes are graphite / electrodes are carbon
electrodes conducts electricity / electrons move in electrodes
hydrogen (ions) go to cathode
chloride (ions) go to the anode
smell of chlorine
electrolyte conducts electricity
ignore: hydroxide ions

[Total: 14]

Example candidate response – grade C

5 **(a)** Match the phrases on the left with the definitions on the right.
The first one has been done for you.



[3]

(b) Sodium hydroxide, NaOH, is an ionic compound which dissolves in water to form a strongly alkaline solution.

(i) Which **one** of the following best describes the pH of a concentrated aqueous solution of sodium hydroxide?
Put a ring around the correct answer.

pH 2 **pH 5** **pH 7** **pH 8** **pH 13** [1]

(ii) Calculate the relative formula mass of sodium hydroxide.

Na O H
relative formula mass = 23 + 16 + 1
= 40

[1]

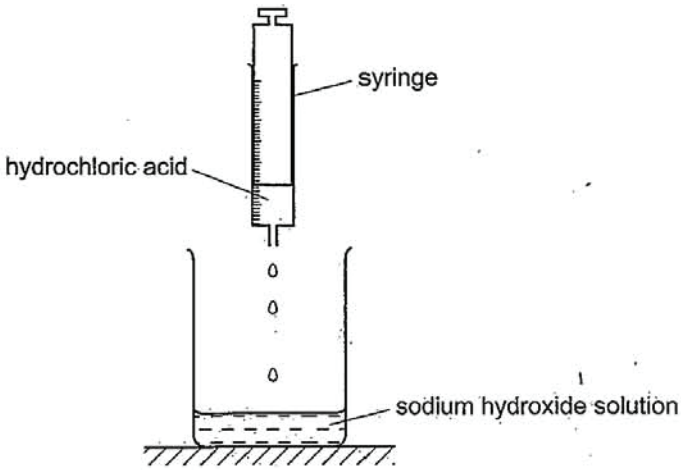
(iii) The equation describes how sodium hydroxide reacts with hydrochloric acid.

$$NaOH + HCl \rightarrow NaCl + H_2O$$

What type of chemical reaction is this?

neutralisation [1]

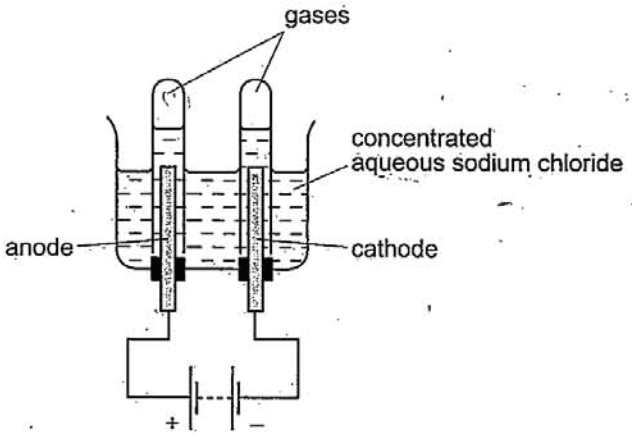
(iv) A student used a syringe to add 1 cm^3 portions of hydrochloric acid to an aqueous solution of sodium hydroxide.



Describe how the pH of the solution in the beaker changes as the hydrochloric acid is added until the acid is in excess.

The solution is less alkaline, so, the pH decreases. Until the acid is in excess, the solution is acidic. (pH < 7) [2]

(c) The diagram shows the apparatus used to electrolyse concentrated aqueous sodium chloride.



Give a description of this electrolysis.
In your description include

- what substance the electrodes are made from and the reason for using this substance
- what you would observe during the electrolysis
- the names of the substances produced at each electrode.

• Electrodes are made from graphite or platinum.
because it is inert.
• The gas bubbles off at anode.
The metal attachs at cathode.
• Anode : chlorine gas
Cathode : Sodium metal

..... [6]

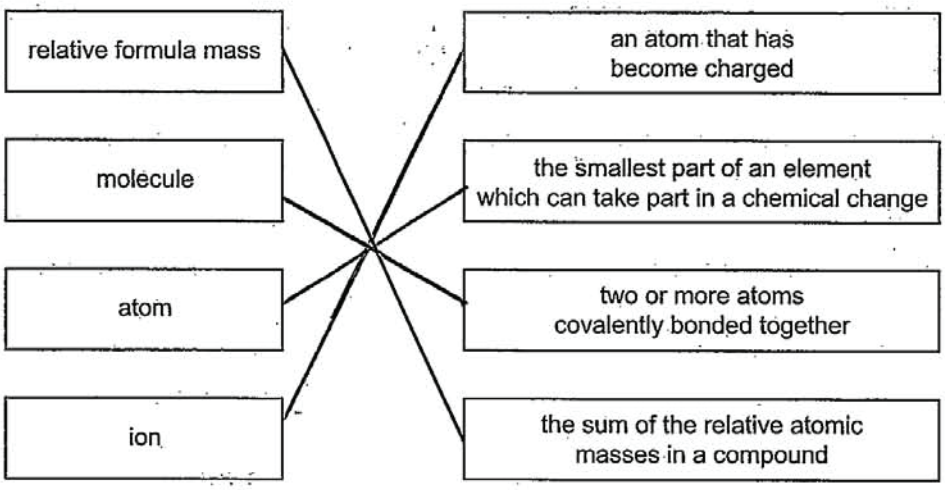
[Total: 14]

Examiner comment – grade C

This answer demonstrates a good understanding of acid-base reactions and definitions. The phrases in **(a)** are perfectly matched with the definitions. The relative formula mass of sodium hydroxide and pH of its solution were both correct. In **(b)(iv)**, the pH changes were well described. The ideas of decreasing pH and going down to less than pH 7 were both present. The extended writing in **(c)** about electrolysis was well laid out in bullet points. It should be borne in mind, however, that the number of points written about should equal the number of marks available, i.e. six marks. In this instance, marks were given for 'electrodes made from graphite', 'gas bubbles at the anode' and 'anode: 'chloride'. Although there were several errors, setting out the answer in this way often results in gaining more marks than in generally writing sentences as they come to mind.

Example candidate response – grade E

5 **(a)** Match the phrases on the left with the definitions on the right.
The first one has been done for you.



[3]

(b) Sodium hydroxide, NaOH, is an ionic compound which dissolves in water to form a strongly alkaline solution.

(i) Which **one** of the following best describes the pH of a concentrated aqueous solution of sodium hydroxide?
Put a ring around the correct answer.

pH 2 **pH 5** **pH 7** **pH 8** **pH 13** [1]

(ii) Calculate the relative formula mass of sodium hydroxide.

NaOH
23+16+1
40

[1]

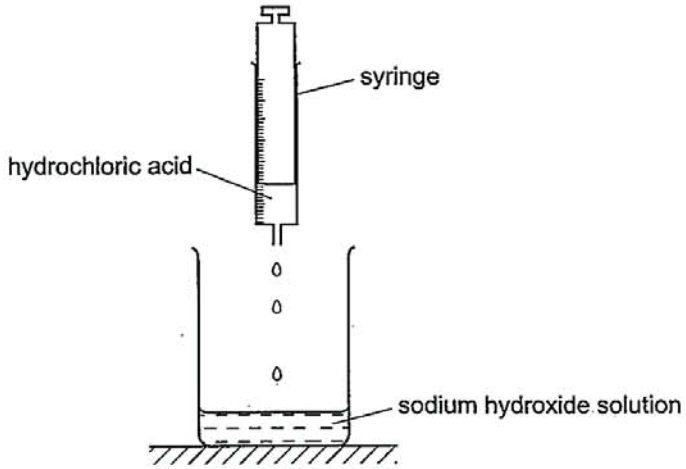
(iii) The equation describes how sodium hydroxide reacts with hydrochloric acid.

$$NaOH + HCl \rightarrow NaCl + H_2O$$

What type of chemical reaction is this?

neutralization ..... [1]

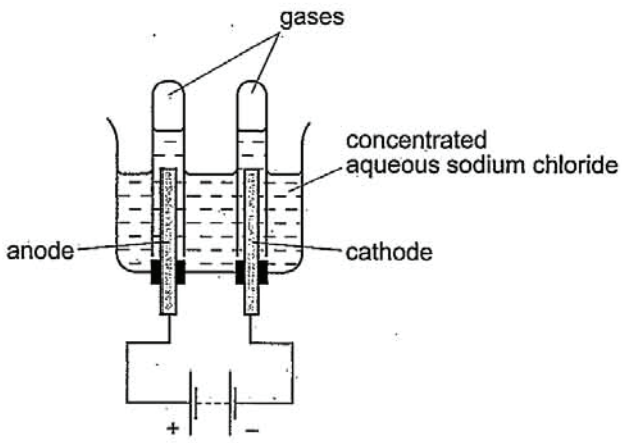
(iv) A student used a syringe to add 1 cm^3 portions of hydrochloric acid to an aqueous solution of sodium hydroxide.



Describe how the pH of the solution in the beaker changes as the hydrochloric acid is added until the acid is in excess.

The pH will first be strong reactive since sodium hydroxide is a base and HCl is an acid until the pH will be neutral [2]

(c) The diagram shows the apparatus used to electrolyse concentrated aqueous sodium chloride.



Give a description of this electrolysis.
In your description include

- what substance the electrodes are made from and the reason for using this substance
- what you would observe during the electrolysis
- the names of the substances produced at each electrode.

→ The electrodes are made from graphite and carbon since graphite ~~is made of~~ has carbon atoms in it.

→ Bubbles will appear and gases will be formed at each electrode.

→ The electrodes will produce a sodium and chlorine gas. [6]

[Total: 14]

Examiner comment – grade E

This answer demonstrates a reasonable understanding of acid-base reactions and a good knowledge of definitions. The phrases in **(a)** are perfectly matched with the definitions. The relative formula mass of sodium hydroxide was correct but the pH selected was too low to be regarded as strongly alkaline. In **(b)(iv)**, the description of the pH changes were too vaguely described for any marks to be awarded. The candidate could have scored the marks if the focus was on the values (numbers) of the pH rather than writing about strong / reactive acids. There was no indication that the pH values were decreasing / going from higher to lower pH values. The extended writing in **(c)**, about electrolysis, was rather short. In this instance marks were given for 'electrodes made from graphite' and 'bubbles will appear'. More marks could have been obtained if the 'help points' were read more carefully. For example, in order to gain the marks for the electrode products, the chlorine and hydrogen should be linked to the anode and cathode.

Question 6

Mark scheme

6 **(a)** as a reducing agent / in the blast furnace / for extracting iron or zinc or other suitable metal / to extract metals / in making lime [1]

(b) **(i)**
layers can slide over each other [1]
both ideas of layers and sliding needed
strong bonding in all directions / covalent bonding in all directions / strong bonding in macromolecules in giant structure [1]
both ideas of type of bonding and giant structure needed

(ii) for cutting / drill bits / for drills [1]

(c) **(i)** ammonium sulfate [1]
ignore: water / hydrogen

(ii) nitrogen [1]

(d) one pair of electrons in each overlap area [1]

(e) 1st box ticked [1]
last box ticked [1]

[Total: 9]

Example candidate response – grade C

6 When coal is heated in the absence of air, coke is formed together with a gas called coal gas and a liquid which contains ammonia.

(a) Coke is largely carbon.
State **one** use of coke in industry.

Its a reducing agent ..... [1]

(b) Two other forms of carbon are diamond and graphite.

(i) Use your knowledge of the structure of diamond and graphite to explain

why graphite is a good lubricant.

The layers of graphite will slip ones each other ..... [1]

why diamond is very hard.

There ~~bonds~~ bonds are very strong in the diamond so it is unbreakable ..... [1]

(ii) Give **one** use of diamond that depends on its hardness.

It is used in drillers which are used in ~~mines~~ mines ..... [1]

(c) The liquid which contains ammonia can be reacted with sulfuric acid.

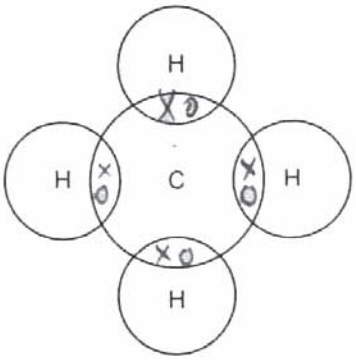
(i) Complete the word equation for this reaction

ammonia + sulfuric acid → ammonium ~~ammonia~~ sulfate [1]

(ii) Which **one** of the following elements do most fertilisers contain?
Put a ring around the correct answer.

chlorine **nitrogen** **sodium** **sulfur** [1]

(d) Coal gas contains methane.
Complete the diagram to show how the electrons are arranged in a molecule of methane.



[1]

(e) When coal is burnt, sulfur dioxide is given off.
Which two of the following statements about sulfur dioxide are correct?
Tick **two** boxes.

Sulfur dioxide is an acidic oxide.	✓
About 20 % of the air is sulfur dioxide.	
Most of the sulfur dioxide in the air comes from car exhausts.	✓
Sulfur dioxide contributes to acid rain.	

[2]

[Total: 9]

Examiner comment – grade C

This answer shows a good understanding of general chemistry and electronic structure. The answers reflect a reasonably good knowledge of structure related to bonding. In **(b)(i)**, the idea of layers in graphite slipping over each other was well described but the explanation of the hardness of diamond did not reflect the strong bonds in all directions and so did not gain the mark. In **(c)(i)**, the correct name, ammonium sulfate, was given. In **(d)**, the electronic structure of methane was well shown with both dots and crosses. In **(e)**, the candidate did not link the acidic nature of sulfur dioxide with acid rain and suggested, incorrectly, that most of the sulfur dioxide in the air comes from car exhausts, so only one mark was given. If candidates realise that most of the sulfur in crude oil is removed before distillation, errors of this type should not arise.

Example candidate response – grade E

6 When coal is heated in the absence of air, coke is formed together with a gas called coal gas and a liquid which contains ammonia.

(a) Coke is largely carbon.
State **one** use of coke in industry.

It is used as a ~~fuel~~ reducing agent [1]

(b) Two other forms of carbon are diamond and graphite.

(i) Use your knowledge of the structure of diamond and graphite to explain

why graphite is a good lubricant.

This is due to the cross holding graphite being weak hence can slide through the other. [1]

why diamond is very hard.

This is due to the bond being equally strongs [1]

(ii) Give **one** use of diamond that depends on its hardness.

Shaping of glasses. [1]

(c) The liquid which contains ammonia can be reacted with sulfuric acid.

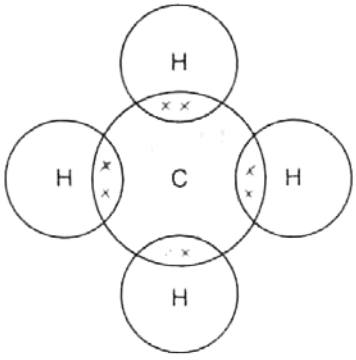
(i) Complete the word equation for this reaction

ammonia + sulfuric acid → Ammonium chloride + Hydrogen [1]

(ii) Which **one** of the following elements do most fertilisers contain?
Put a ring around the correct answer.

chlorine **(nitrogen)** **sodium** **sulfur** [1]

(d) Coal gas contains methane.
Complete the diagram to show how the electrons are arranged in a molecule of methane.



[1]

(e) When coal is burnt, sulfur dioxide is given off.
Which two of the following statements about sulfur dioxide are correct?
Tick **two** boxes.

Sulfur dioxide is an acidic oxide.	☐
About 20 % of the air is sulfur dioxide.	☐
Most of the sulfur dioxide in the air comes from car exhausts.	✓
Sulfur dioxide contributes to acid rain.	✓

[2]

[Total: 9]

Examiner comment – grade E

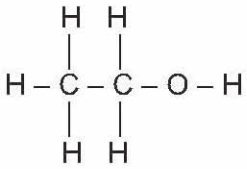
This answer shows some understanding of general chemistry and electronic structure. The answers requiring extended writing are rather vague and hence gained no mark. In **(b)(i)**, there was no idea of layers in graphite slipping over each other. The answer implies that the forces are weak and these forces slide over each other. The explanation of the hardness of diamond does not reflect the strong bonds in all directions, just to the bonds being equally strong. This did not, therefore, gain the mark. In **(b)(ii)**, 'the shaping of glasses' is too vague to warrant credit. In **(c)(i)**, two products were given. If a single line is given, it only requires one product, rather than two. In **(d)**, the electronic structure of methane is correct even though the electrons are only shown as crosses. In part **(e)**, the candidate did not link acid rain with the acidic nature of sulfur dioxide and suggested, incorrectly, that most of the sulfur dioxide in the air comes from car exhausts, so only one mark was given. If students realise that most of the sulfur in crude oil is removed before distillation, errors of this type should not arise.

Question 7

Mark scheme

7 (a) (i) Any two of: [2]
have same general formula / have same pattern of formula / members differ by CH_2 group
have same functional group
have similar chemical properties / prepared by similar methods
allow: same chemical properties
not: similar properties
show gradual change in physical properties / show trend in boiling points

(ii)



allow: OH in place of O – H [1]

(b) (i) exothermic and temperature increases / goes from 18 to 37 [1]
both: exothermic and temperature increase needed for the mark
allow: exothermic because heat is given off

(ii) grey / black / grey-black [1]
not: brown / purple

(c) filter (off zinc); [1]
note: second mark dependent on filtration for first mark
(let alcohol) evaporate / evaporate (off the alcohol) [1]
allow: warm gently (to remove some alcohol)
allow: use drying agent
ignore: heat unqualified / crystallise
reject: residue left to dry

(d) (i) ZnI_2 [1]
allow: $5ZnI_2$

(ii) 2nd answer ringed (giant ionic) [1]
allow: underlined or ticked

(e) 1 mark for each product [3]
zinc nitrate
ammonium nitrate **not:** ammonia nitrate
water

(f) add (aqueous) sodium hydroxide (and warm) [1]
test gas evolved with red litmus paper/ universal indicator paper [1]
litmus paper/ universal indicator paper turns blue [1]
note: the 2nd and 3rd marks are dependent on the first mark being correct

[Total: 15]

Example candidate response – grade C

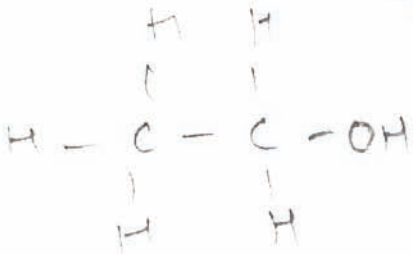
7 Ethanol, C_2H_5OH, is a member of the alcohol homologous series.

(a) **(i)** Give **two** characteristics of a homologous series.

1. same general formula
2. same sw ee structure [2]

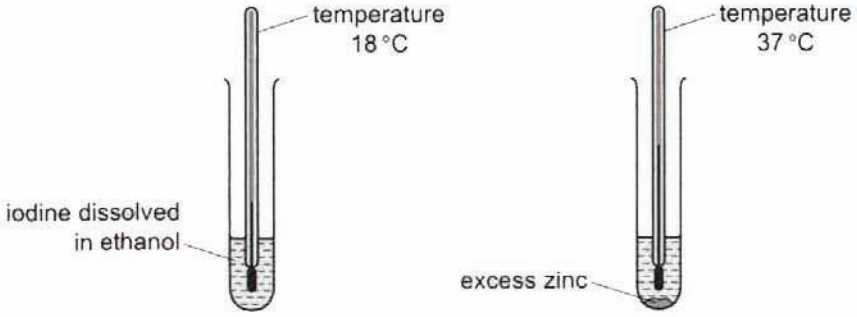
(ii) Draw the structure of ethanol showing all atoms and bonds.

C_2H_5OH



[1]

(b) One use of ethanol is as a solvent.
A pupil studied the reaction of iodine with zinc.
She first dissolved a few crystals of iodine in ethanol and recorded the temperature of the solution.
The temperature was 18 °C.
She then added excess powdered zinc and recorded the temperature again.
The new temperature was 37 °C.



(i) Is this reaction endothermic or exothermic?
Explain your answer.

exothermic reaction because temperature rise. [1]

(ii) What colour is solid iodine?

blue [1]

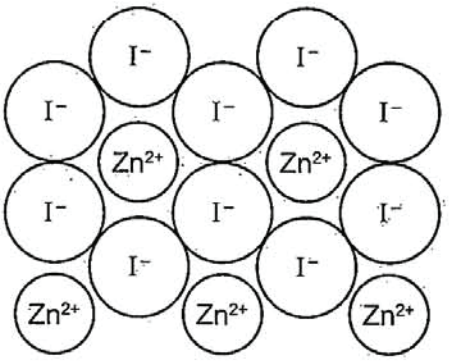
(c) The equation for the reaction is

zinc + iodine → zinc iodide

When the reaction is complete, the mixture contains zinc iodide dissolved in ethanol and unreacted zinc powder.
Suggest how you can get crystals of zinc iodide from the reaction mixture.

when we heat zinc iodide the crystal will be form from the form from the reaction. [2]

(d) The diagram shows the structure of zinc iodide.



(i) What is the simplest formula for zinc iodide?

ZO_2 [1]

(ii) The list below shows four different types of structure.
What type of structure is zinc iodide?
Put a ring around the correct answer.

giant covalent

giant ionic

metallic

molecular

[1]

(e) The equation for the reaction of zinc with dilute nitric acid is

$$4Zn + 10HNO_3 \rightarrow 4Zn(NO_3)_2 + NH_4NO_3 + 3H_2O$$

Write a word equation for this reaction.

zinc + nitric acid → zinc nitrate + ammonium nitrate + water. [3]

(f) Describe a test for ammonium ions.

test React with sodium hydroxide

result it will give a ammonia and it will give white precipitate [3]

[Total: 15]

Examiner comment – grade C

This answer demonstrates a reasonably good understanding of organic chemistry and a good ability at writing word equations. In **(a)(ii)**, the structure of ethanol was well drawn, although the O–H bond could also have been shown. However, knowledge of practical procedures **(c)**, including qualitiative analysis **(f)**, was weaker. In **(a)(i)**, the idea of homologous series having the 'same general formula' was well explained but 'the same structure' was too vague to be awarded a mark. In (**c)**, the idea of heating (to evaporate the alcohol) did not go far enough. The major error was to omit the filtration step. The marks for this part could have been obtained by first referring to the stem of the question and then considering the state of zinc and the solution of iodine in alcohol. In questions involving separations, it is important to first consider the states of the components of the mixture to be separated. In **(d)(i)**, the mark was not obtained through not checking the diagram sufficiently. The answer ZnO_2 had a 1:2 ratio but the wrong anion (oxide substituted for iodide). In **(e)**, all the products were correctly identified. At this level the correct identification of 'ammonium nitrate' was a common distinguishing feature between grade C and E candidates. In **(f)**, the reagent, sodium hydroxide was correct but observations were not given. The candidate did have the idea that the test released ammonia, but no test for ammonia was given. As in **2(c)(i)**, more marks could have been obtained by focusing on observations rather than naming products.

Example candidate response – grade E

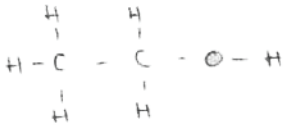
7 Ethanol, C_2H_5OH, is a member of the alcohol homologous series.

(a) (i) Give **two** characteristics of a homologous series.

1. They have the same structure formula

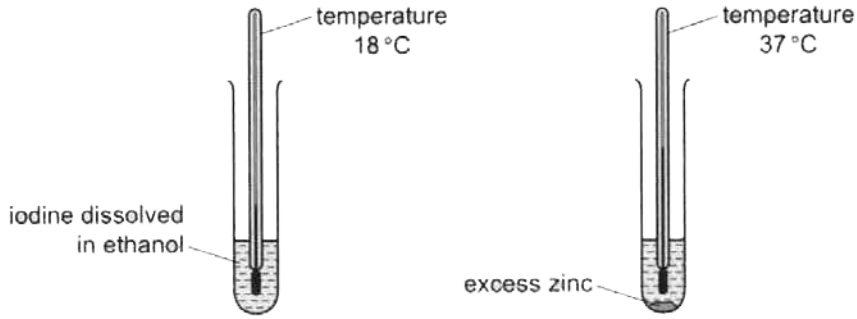
2. They have a difference of 2 Carbon atom [2]

(ii) Draw the structure of ethanol showing all atoms and bonds.



[1]

(b) One use of ethanol is as a solvent.
A pupil studied the reaction of iodine with zinc.
She first dissolved a few crystals of iodine in ethanol and recorded the temperature of the solution.
The temperature was 18 °C.
She then added excess powdered zinc and recorded the temperature again.
The new temperature was 37 °C.



(i) Is this reaction endothermic or exothermic?
Explain your answer.

Exothermic. Yes, because it realeased heat to the surroundings. [1]

(ii) What colour is solid iodine?

Reddish [1]

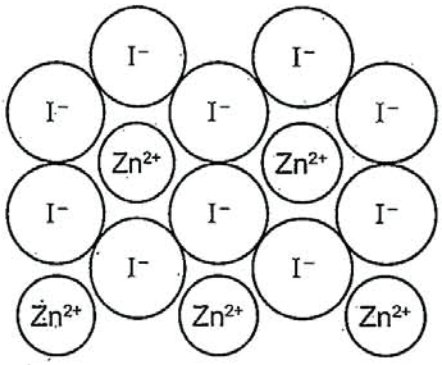
(c) The equation for the reaction is

$$\text{zinc} + \text{iodine} \rightarrow \text{zinc iodide}$$

When the reaction is complete, the mixture contains zinc iodide dissolved in ethanol and unreacted zinc powder.
Suggest how you can get crystals of zinc iodide from the reaction mixture.

This is by using evaporation method, whereby, zinc iodide dissolved in ethanol will be released hence unreacted zinc powder will be obtained. [2]

(d) The diagram shows the structure of zinc iodide.



(i) What is the simplest formula for zinc iodide?

ZnI [1]

(ii) The list below shows four different types of structure.
What type of structure is zinc iodide?
Put a ring around the correct answer.

giant covalent

giant ionic

metallic

molecular

[1]

(e) The equation for the reaction of zinc with dilute nitric acid is

$$4Zn + 10HNO_3 \rightarrow 4Zn(NO_3)_2 + NH_4NO_3 + 3H_2O$$

Write a word equation for this reaction.

Zinc + hydrogen ~~nitrate~~ nitride → Zinc nitrate + Ammonia nitrate + Water [3]

(f) Describe a test for ammonium ions.

test By adding sodium hydroxide

result There will be a yellow precipitate formed in the solution. [3]

[Total: 15]

Examiner comment – grade E

This answer demonstrates some understanding of organic chemistry and a moderate ability at writing word equations. In **(a)(ii)**, the structure of ethanol was well drawn, showing all atoms and bonds. Practical procedures **(c)** including qualitative analysis **(f)** could have been improved. In **(a)(i)**, the idea of homologous series' was hinted at but written about too vaguely and with incorrect terminology, e.g. 'the same structural formula' rather than the same general formula, and 'they have a difference in 2 carbon atoms' rather than a CH_2 group. In **(c)**, the idea of heating was the major error was to omit after the filtration step. The marks for this part could have been obtained by first referring to the stem of the question and a consideration of the state of zinc and the solution of iodine in alcohol. In questions involving separations, it is important to first consider the states of the components of the mixture to be separated. In **(d)(i)**, the mark was not obtained through not counting the ions in the diagram. In **(e)**, two of the products were correctly identified. At this level the incorrect identification of NH_4NO_3 as 'ammonia nitrate' was a common distinguishing feature between grade C and E candidates. In **(f)**, the reagent, sodium hydroxide was correct but a precipitate was referred to rather than a gas. More marks could have been obtained for this question by learning the tests for qualitative analysis for Paper 2.

Paper 3 – Extended theory

Paper 3 is a written, extended theory paper consisting of short-answer and structured questions. Questions will be based on the Extended curriculum and will be of a difficulty appropriate to the higher grades. Questions will test skills mainly in assessment objectives A (Knowledge with understanding) and B (Handling information and problem solving). A quarter of the marks available will be based on Core material and the remainder on the Supplement.

Question 1

Mark scheme

1 (a) 27p 32n 27e [1]
27p 32n 25e [1]

(b) (i) same proton number / same number of protons / same atomic number [1]
different nucleon number / different number of neutrons / different mass number [1]

(ii) same electron distribution [1]
allow: same proton number and same number of electrons
not: same number of electrons / same number of shells

(iii) industrial detection of leaks / thickness of paper etc. / nuclear fuel for generating electricity / nuclear weapons / radiographs of welds / measuring wear / sterilising food [1]
not: carbon dating

medical treatment of cancer, radiotherapy, treatment of thyroid gland, X rays, tracer studies in body, sterilising equipment, locating tumours
accept: X-rays only once [1]

Example candidate response – grade A

1. Cobalt is an element in Period 4 of the Periodic Table.

(a) Use your copy of the Periodic Table to help you complete the table below.

particle	number of protons	number of neutrons	number of electrons
Co	27	32	27
Co^{2+}	27	32	25

[2]

(b) ^{60}Co is a cobalt isotope.

(i) Explain the term *isotope*.

An atom with the same number of protons but a different number of neutrons.

[2]

(ii) Explain why two isotopes of the same element have identical chemical properties.

They've got the same number of protons and are in the same position in the periodic table. [1]

(iii) State **one** industrial use and **one** medical use of radioactive isotopes.

industrial use Electricity generation [1]

medical use Treating cancer [1]

[Total: 7]

Examiner comment – grade A

(a) Both rows in the table are correct. Particularly creditable was the recognition that the positive charge on the cobalt ion was due to the atom having lost two electrons.

(b) (i) The response gave the two essential points - same number of protons but a different number of neutrons.

(ii) One of two explanations was awarded the mark, either the same number of protons or the same electron distribution. The candidate gave the first alternative.

(iii) Both uses were accepted. The first answer would be improved by the addition of the phrase 'in nuclear reactors'.

Example candidate response – grade C

1 Cobalt is an element in Period 4 of the Periodic Table.

(a) Use your copy of the Periodic Table to help you complete the table below.

particle	number of protons	number of neutrons	number of electrons
Co	27	32	27
Co^{2+}	25	32	25

[2]

(b) ^{60}Co is a cobalt isotope.

(i) Explain the term *isotope*.

An element with the same number of protons and electrons but different number of neutrons. [2]

(ii) Explain why two isotopes of the same element have identical chemical properties.

They have the same number of electrons [1]

(iii) State **one** industrial use and **one** medical use of radioactive isotopes.

industrial use Manufacture of weapons and bombs. [1]

medical use ~~Clean~~ Sterilise medical equipment [1]

[Total: 7]

Examiner comment – grade C

(a) The first row in the table is correct but the second row is incorrect. The number of protons should be unchanged, only electrons are lost when a positive ion is formed.

(b) (i) The response gave the two essential points – same number of protons but different number of neutrons. The number of electrons do not have to be the same in isotopic particles; this is only true if both particles are atoms. It was decided to ignore any comment about the same number of electrons and focus on the number of protons and neutrons.

(ii) They have the *same number of protons* or the *same electron distribution* were the preferred explanations.

(iii) Two correct uses are given.

Example candidate response – grade E

1 Cobalt is an element in Period 4 of the Periodic Table.

(a) Use your copy of the Periodic Table to help you complete the table below.

particle	number of protons	number of neutrons	number of electrons
Co	27	32	27
Co^{2+}			

[2]

(b) ^{60}Co is a cobalt isotope.

(i) Explain the term *isotope*.

Isotope is the ability of an element to have two different mass number but the same atomic number. [2]

(ii) Explain why two isotopes of the same element have identical chemical properties.

It is because ~~the~~ their ionic substance are the same and it is the same element. [1]

(iii) State **one** industrial use and **one** medical use of radioactive isotopes.

industrial use ..... [1]

medical use ..... [1]

[Total: 7]

Examiner comment – grade E

(a) This script shows a common outcome, the candidate was familiar the composition of atoms in terms of the numbers of electrons, protons and neutrons but could not account for the existence of an ionic charge in terms of electron loss or gain. The only difference between the cobalt atom and the cobalt(II) ion is two electrons less in the ion.

(b) (i) An alternative, but acceptable, explanation of the term isotope was given.

(ii) The response does not refer to either the same number of protons or the same electron distribution. No marks could be awarded.

(iii) This part was not attempted.

Question 2

Mark scheme

2 (a) burns to form sulfur dioxide [1]
acid rain / any problem associated with acid rain / sulfur dioxide is poisonous [1]

(b) (i) bigger surface area [1]
burns / reacts faster / greater number of collisions [1]
not: more sulfur dioxide

(ii) kills microbes / bacteria / fungi etc. [1]
accept: anti-oxidant / stops oxygen oxidising juice / prevents growth of bacteria

(iii) bleach / refrigerant / making wine / fumigant /insecticide / dyes [1]
not: making sulfuric acid

(c) $2SO_2 + O_2 \rightarrow 2SO_3$ [1]
temperature 400 to 450 °C [1]
pressure 1 to 10 atmospheres [1]
catalystvanadium(V) oxide / vanadium oxide [1]

(d) $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$ [1]
$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$ [1]

Example candidate response – grade A

2 Sulfur is needed for the production of sulfuric acid. Two of the major sources of sulfur are

- underground deposits of the element sulfur,
- sulfur compounds from natural gas and petroleum.

(a) Explain why sulfur and its compounds are removed from these fuels before they are burned.

The fuels will burst in flame when burned and it would be dangerous. [2]

(b) Sulfur dioxide is made by spraying molten sulfur into air. The sulfur ignites and sulfur dioxide is formed.

(i) Suggest why molten sulfur is used in the form of a fine spray.

It ~~spea~~ spreads faster and it will have a greater surface area to volume ratio [2]

(ii) Explain why traces of sulfur dioxide act as a preservative in fruit juices.

Sulfur dioxide prevents bacteria from accumulating. [1]

(iii) State another use of sulfur dioxide.

To make fertilizers. [1]

(c) Describe how sulfur dioxide is changed into sulfur trioxide. Give the reaction conditions and an equation.

Oxygen is added to sulfur dioxide. This occurs at a temperature of 450°C, a pressure of 1 atm and vanadium oxide is the catalyst.

$2SO_2 + O_2 \rightleftharpoons 2SO_3$ [4]

(d) Complete the following equations for the formation of sulfuric acid from sulfur trioxide.

$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$

$H_2S_2O_7 + H_2O \rightarrow 2\ H_2SO_4$ [2]

[Total: 12]

Examiner comment – grade A

(a) The correct reason is that sulfur in the fuels would burn to form sulfur dioxide. In the atmosphere, this gas forms acid rain. This has adverse effects on health and on the environment.

(b) **(i)** Faster reaction rate due to increased surface area warrants the award of both marks. This is an excellent answer.

(ii) The explanation just about justifies the award of the mark. Possibly sulfur dioxide kills micro-organisms would be a better response.

(iii) Sulfur dioxide is not used directly to make fertilisers. Uses of sulfur dioxide include as a bleach for silk or wood pulp, as a fumigant, as a refrigerant, or to make dyes .

(c) Commendably, the complete description was given – pressure, temperature, catalyst and the equation.

(d) Both equations are correct.

Example candidate response – grade C

2 Sulfur is needed for the production of sulfuric acid. Two of the major sources of sulfur are

- underground deposits of the element sulfur,
- sulfur compounds from natural gas and petroleum.

(a) Explain why sulfur and its compounds are removed from these fuels before they are burned.

because they form sulphur dioxide ~~and~~ and mix with water in the atmosphere ~~and~~ and ~~can~~ result in the production of suphorous acid which will cause acid rain [2]

(b) Sulfur dioxide is made by spraying molten sulfur into air. The sulfur ignites and sulfur dioxide is formed.

(i) Suggest why molten sulfur is used in the form of a fine spray.

They have large surface area and are ~~greater~~ greater exposed to air [2]

(ii) Explain why traces of sulfur dioxide act as a preservative in fruit juices.

Sulfur dioxide forms sulphuric acid ~~which~~. [1]

(iii) State another use of sulfur dioxide.

in making sulphuric acid, Oleum, protects it from bacteria bacteria cannot live in acid. [1]

(c) Describe how sulfur dioxide is changed into sulfur trioxide. Give the reaction conditions and an equation.

It is made to react with Oxygen. $2SO_2 + O_2 \rightarrow 2SO_3$, It needs 2 atmospheric pressure, 450°c and Vanadium Pentoxide as a catalyst. It ~~is~~ then [4]

(d) Complete the following equations for the formation of sulfuric acid from sulfur trioxide.

$2\,SO_3 + \ldots H_2O \ldots \rightarrow H_2S_2O_7$

$H_2S_2O_7 + \ldots H_2O \ldots \rightarrow \ldots 2 \ldots H_2SO_4$ [2]

[Total: 12]

Examiner comment – grade C

(a) This a very good answer, it includes the two essential points – the formation of sulfur dioxide and the consequent formation of acid rain.

(b) **(i)** The spray has a large surface area is mentioned but not that it would cause a fast reaction rate. Only one of the two marks could be awarded.

(ii) The correct explanation is that sulfur dioxide kills the micro-organisms which are responsible for the decomposition of fruit juice.

(iii) Sulfur dioxide is used to make sulfuric acid is given in the question. Other uses of sulfur dioxide include a bleach for silk or wood pulp, a fumigant, a refrigerant, or to make dyes .

(c) The description includes the four marking points - pressure, temperature, catalyst and the equation. It would have been prudent to include the reversible arrow in the equation; this might have been required for the award of the equation mark.

(d) Both equations are correct. The equation $2SO_3 + H_2O \rightarrow H_2S_2O_7$ is accepted as an alternative to the more usual version $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$

Example candidate response – grade E

2 Sulfur is needed for the production of sulfuric acid. Two of the major sources of sulfur are

- underground deposits of the element sulfur,
- sulfur compounds from natural gas and petroleum.

(a) Explain why sulfur and its compounds are removed from these fuels before they are burned.

When sulfur is burned and released it mixes with oxygen to form sulfuric acid which is a dangerous gas [2]

(b) Sulfur dioxide is made by spraying molten sulfur into air. The sulfur ignites and sulfur dioxide is formed.

(i) Suggest why molten sulfur is used in the form of a fine spray.

in order for it to react with air easily. [2]

(ii) Explain why traces of sulfur dioxide act as a preservative in fruit juices.

It helps kill bacteria [1]

(iii) State another use of sulfur dioxide.

As a bleaching agent [1]

(c) Describe how sulfur dioxide is changed into sulfur trioxide. Give the reaction conditions and an equation.

In the presence of air sulphur ~~reacts~~dioxide reacts with the oxygen present to produce sulphurtrioxide

$2SO_2 + O_2 \longrightarrow 2SO_3$ [4]

(d) Complete the following equations for the formation of sulfuric acid from sulfur trioxide.

$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$

$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$ [2]

[Total: 12]

Examiner comment – grade E

(a) The required explanation is that sulfur dioxide would form and become acid rain with its deleterious effects on health and the environment. The response had to mention sulfur dioxide to justify the award of any marks.

(b) (i) The explanation did not mention the large surface area of the droplets and a fast reaction rate so no marks could be awarded.

(ii) The role of sulfur dioxide as a preservative for fruit juice and food relies on its ability to kill micro-organisms. This was referred to in the answer.

(iii) Sulfur dioxide is used as a bleach.

(c) Only the equation warrants the award of a mark. Temperature, pressure and catalyst are not mentioned.

(d) Both equations are correct.

Question 3

Mark scheme

3 (a) (i) heat / roast in air / oxygen [1]
accept: burn in air / oxygen

(ii) (reduce) with carbon / carbon monoxide [1]

(b) test it with both hydrochloric acid and sodium hydroxide(aq) [1]
accept: any named strong acid and any strong alkali
if only acid and alkali given then max = 3
basic oxide reacts with acid [1]
acidic oxide reacts with alkali/base [1]
amphoteric reacts with both [1]
accept: for react – form salt and water

(c) (i) at equilibrium [1]
rate of forward reaction equals rate of back reaction / concentrations remain constant / macroscopic properties do not change with time [1]
accept: amounts do not change with time

(ii) equilibrium moves to left (SbOC*l* used up) [1]
hydrochloric acid removed by reacting with SbOC*l*
precipitate dissolves in hydrochloric acid

(iii) add water / dilute / add an alkali / add more $SbCl_3$ / add a base / add a carbonate [1]

Example candidate response – grade A

3 Antimony, Sb, is an element in Group V.

(a) The main ore of antimony is its sulfide. The extraction of antimony is similar to that of zinc.
Describe how each of these changes in the extraction of antimony is carried out.

(i) antimony sulfide to antimony oxide

Sb S — $Sb_2S + O_2 \rightarrow$

React antimony sulfide with oxygen [1]

(ii) antimony oxide to antimony

React antimony oxide with a reducing agent e.g. carbon [1]

(b) Antimony oxide is a white powder which is insoluble in water.
Describe how you would find out if it is a basic, an acidic or an amphoteric oxide.

I would take two samples of antimony oxide, with one I will add HCl(aq) and the other I would add NaOH(aq). If it forms a salt with NaOH it is an acid. If it has no reaction with NaOH it is a base. ~~It forms a salt with HCl it is base.~~ If it reacts with both HCl and NaOH it is an amphoteric oxide. [4]

(c) When antimony chloride is added to water, a faint white precipitate forms and the mixture slowly goes cloudy.

$$SbCl_3(aq) + H_2O(l) \underset{\text{backward}}{\overset{\text{forward}}{\rightleftharpoons}} 2HCl(aq) + SbOCl(s)$$

colourless white

(i) Explain why after some time the appearance of the mixture remains unchanged.

The reaction has finished. All reagents would have finish reacting with each other. [2]

(ii) When a few drops of concentrated hydrochloric acid are added to the mixture, it changes to a colourless solution. Suggest an explanation.

The reaction is reversible. ~~The antimony chloride dissolves~~ The solution dissolve back to antimony chloride and water. ~~(the reaction is reverse~~ [1]

(iii) Suggest how you could make the colourless solution go cloudy.

Add more water. [1]

[Total: 10]

Examiner comment – grade A

(a) **(i)** The required description was that the antimony sulfide was heated/burnt/roasted in air/ oxygen. The need to heat the ore was not mentioned.

(ii) A correct reducing agent was specified.

(b) The only error was to omit stating that basic oxides react with an acid. It is not sufficient to state that they do not react with a base. This is equally true of neutral oxides.

The other three marking points were given:
the alkali and strong acid were named,
if the oxide reacts with an alkali it is acidic,
if the oxide reacts with both strong acid and alkali it is amphoteric.

(c) **(i)** It was not appreciated that the reaction is at equilibrium and the rate of the forward and back reactions are equal, or macroscopic properties do not change with time.

(ii) The candidate realised that the addition of hydrochloric acid would favour the back reaction and was awarded the mark.

(iii) To make the mixture go cloudy the position of equilibrium needs to move to the right. This can be achieved, as suggested by the candidate, by the addition of water. An alternative method would be to add a base.

Example candidate response – grade C

3 Antimony, Sb, is an element in Group V.

(a) The main ore of antimony is its sulfide. The extraction of antimony is similar to that of zinc.
Describe how each of these changes in the extraction of antimony is carried out.

(i) antimony sulfide to antimony oxide

reaction with base ..... [1]

(ii) antimony oxide to antimony

reduction with carbon ..... [1]

(b) Antimony oxide is a white powder which is insoluble in water.
Describe how you would find out if it is a basic, an acidic or an amphoteric oxide.

~~use its~~ melt it, test with ~~universal~~ indicator paper if litmus paper turns red, it is acid, so, it can react with base.

..... [4]

(c) When antimony chloride is added to water, a faint white precipitate forms and the mixture slowly goes cloudy.

$$\underset{\text{colourless}}{SbCl_3(aq)} + H_2O(l) \underset{\text{backward}}{\overset{\text{forward}}{\rightleftharpoons}} 2HCl(aq) + \underset{\text{white}}{SbOCl(s)}$$

(i) Explain why after some time the appearance of the mixture remains unchanged.

because the $SbCl_3$ has been used up.

..... [2]

(ii) When a few drops of concentrated hydrochloric acid are added to the mixture, it changes to a colourless solution. Suggest an explanation.

because the oxygen in SbOCl will bond with hydrogen from HCl to ~~be~~ form water (no SbOCl anymore) ..... [1]

(iii) Suggest how you could make the colourless solution go cloudy.

add carbon, stir the solution, CO_2 will be formed, ~~then~~ ~~the mixture~~ then, blow the ~~it~~ ..... [1]

[Total: 10]

Examiner comment – grade C

(a) **(i)** The required description was that the antimony sulfide was heated/burnt/roasted in air/oxygen. The suggestion to use a base is without any relevance to the question.

(ii) A correct reducing agent, carbon, was specified.

(b) The use of litmus paper is incorrect because the oxide is insoluble in water. The correct procedure, which involves the use of a named alkali and a named strong acid, is described previously.

(c) **(i)** The antimony chloride is not used up, the reaction is at equilibrium and the rates of the forward and back reactions are equal, or the concentrations do not change with time.

(ii) The explanation given was accepted, but one in terms of the position of equilibrium would have been preferable.

(iii) Presumably the candidate was thinking of carbon dioxide and limewater as an explanation of going cloudy. This misconception stems from a lack of awareness that the system is at equilibrium. The position of equilibrium needs to move to the right; this can be achieved by the addition of water or a base.

Example candidate response – grade E

3 Antimony, Sb, is an element in Group V.

(a) The main ore of antimony is its sulfide. The extraction of antimony is similar to that of zinc.
Describe how each of these changes in the extraction of antimony is carried out.

(i) antimony sulfide to antimony oxide $Sb_2S_4 \rightarrow Sb_2O + SO_3$

$Sb_2S_4 \longrightarrow Sb_2O + SO_3$ [1]

(ii) antimony oxide to antimony Sb

$Sb_2O \longrightarrow Sb + O_2$ [1]

(b) Antimony oxide is a white powder which is insoluble in water.
Describe how you would find out if it is a basic, an acidic or an amphoteric oxide.

by getting a beaker than but the antimony oxide in the water and get indicator paper and see the colour would change or be colourless

[4]

(c) When antimony chloride is added to water, a faint white precipitate forms and the mixture slowly goes cloudy.

$$SbCl_3(aq) + H_2O(l) \underset{\text{backward}}{\overset{\text{forward}}{\rightleftharpoons}} 2HCl(aq) + SbOCl(s)$$

colourless white

(i) Explain why after some time the appearance of the mixture remains unchanged.

because the reaction stops ~~be~~ due to no ~~any~~ excess [2]

(ii) When a few drops of concentrated hydrochloric acid are added to the mixture, it changes to a colourless solution. Suggest an explanation.

due to the more reaction of Hcl with Sb_2Cl so the colourless soloution be more than the white [1]

(iii) Suggest how you could make the colourless solution go cloudy.

by put more water than small amount of $SbCl_3$ [1]

[Total: 10]

Examiner comment – grade E

(a) **(i)** The equation given on the script has no relevance to the question. The correct description is given above – burn the sulfide in air or oxygen.

(ii) A correct reducing agent was needed that is carbon or carbon monoxide.

(b) Indicator paper would not react to an insoluble oxide. The correct procedure involves the use of a named alkali and a named strong acid and is described previously.

(c) **(i)** The reaction does not stop. Reversible reactions come to a dynamic equilibrium when the concentrations do not alter with time.

(ii) The comment does indicate that the back reaction occurs so it was awarded the mark. A better explanation would have referred to the movement of the position of equilibrium.

(iii) The addition of water would move the position of equilibrium to the right. The mark could be awarded.

Question 4

Mark scheme

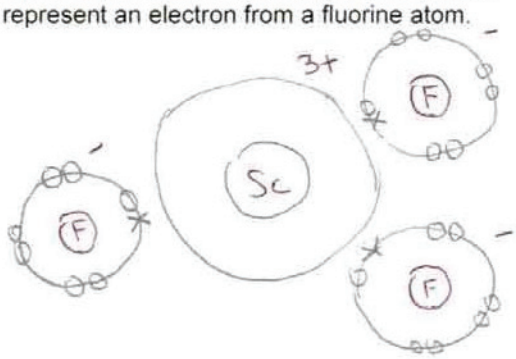
4	(a)	(i)	ScF3	[1]
			correct charges	[1]
			7o and 1x around fluorine	[1]
		(ii)	strong forces / bonds between ions **accept:** lattice as alternative to bonds / requires a lot of energy to break bond between ions **not:** giant molecular / IMFs	[1]
	(b)	(i)	1Si surrounded by 4O	[1]
			1O surrounded by 2Si	[1]
			looks or stated to be tetrahedral	[1]
		(ii)	silicon(IV) oxide does not conduct and (molten) scandium fluoride does conduct **not:** good and poor	[1]
		(iii)	scandium fluoride contains ions (silicon(IV) oxide does not)	[1]
			ions can move when molten or in solution	[1]

Example candidate response – grade A

4 The structure of an element or compound determines its physical properties.
Scandium fluoride and silicon(IV) oxide have giant structures.

(a) Scandium fluoride is an ionic compound.

(i) The valency of scandium is three. Draw a diagram which shows the formula of the compound, the charges on the ions and the arrangement of the valency electrons around the negative ion.
Use x to represent an electron from a scandium atom.
Use o to represent an electron from a fluorine atom.



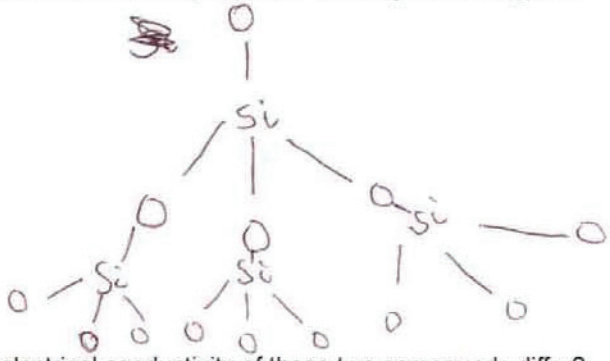
[3]

(ii) The melting point of scandium fluoride is 1552 °C. Explain why scandium fluoride has a high melting point.

High energy is need to break strong ionic bonds in the compound. [1]

(b) Silicon(IV) oxide has a macromolecular structure.

(i) Describe the structure of silicon(IV) oxide. You may use a diagram.



[3]

(ii) How does the electrical conductivity of these two compounds differ?

Scandium flouride conducts electricity in molten state while silicon oxide does not. [1]

(iii) Explain the difference in conductivity.

Scandium flouride is a good conductor while silicon (IV) oxide is not. [2]

[Total: 10]

Examiner comment – grade A

(a) (i) An excellent answer which includes all the required information in the form of a clearly presented diagram. This gives the correct formula of the compound, the charges on the ions and the arrangement of the electrons around the anion.

(ii) The essential idea is given – there are strong bonds between the ions.

(b) (i) Another clear diagram which includes all the essential features which are:
4 O atoms around each Si atom
2Si atoms around each O atom
tetrahedral shape

(b) (ii) All that was required was that scandium fluoride conducts and silicon(IV) oxide does not. This was given in the answer.

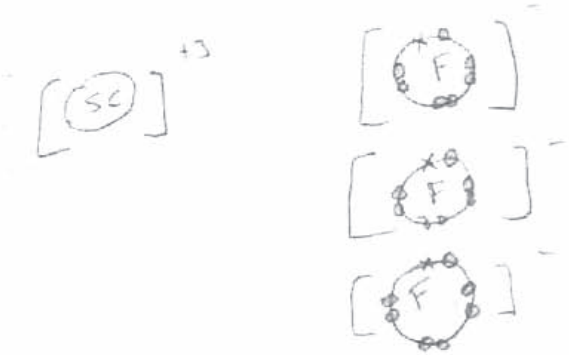
(iii) The candidate has simply repeated the answer to **(b)(ii)**. A reason for the difference in electrical conductivity is needed. Scandium fluoride contains ions which can move in the liquid state, silicon(IV) oxide does not.

Example candidate response – grade C

4 The structure of an element or compound determines its physical properties.
Scandium fluoride and silicon(IV) oxide have giant structures.

(a) Scandium fluoride is an ionic compound.

(i) The valency of scandium is three. Draw a diagram which shows the formula of the compound, the charges on the ions and the arrangement of the valency electrons around the negative ion.
Use x to represent an electron from a scandium atom.
Use o to represent an electron from a fluorine atom.



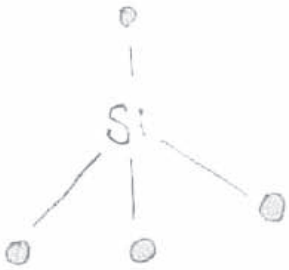
[3]

(ii) The melting point of scandium fluoride is 1552 °C. Explain why scandium fluoride has a high melting point.

As the it is ionic compound and its bonds need more energy to be broken [1]

(b) Silicon(IV) oxide has a macromolecular structure.

(i) Describe the structure of silicon(IV) oxide. You may use a diagram.



[3]

(ii) How does the electrical conductivity of these two compounds differ?

Silicon (IV) oxide does not conduct electricity while Scandium fluoride does conduct. [1]

(iii) Explain the difference in conductivity.

Scandium fluoride have free moving ions while Silicon oxide does not have [2]

[Total: 10]

Examiner comment – grade C

(a) (i) Another excellent answer clearly presented and including all the correct ideas.

(ii) The explanation needs the explicit comment that there are strong ionic bonds.

(b) (i) The diagram did not show that there are 2Si atoms around each O atom.

(ii) The difference in electrical conductivity was stated precisely.

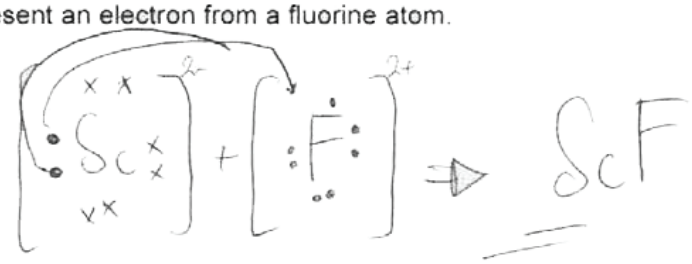
(iii) The explanation should make it clear that only the scandium fluoride has ions and these can move in the liquid phase. There is ambiguity in the candidate's answer.

Example candidate response – grade E

4 The structure of an element or compound determines its physical properties.
Scandium fluoride and silicon(IV) oxide have giant structures.

(a) Scandium fluoride is an ionic compound.

(i) The valency of scandium is three. Draw a diagram which shows the formula of the compound, the charges on the ions and the arrangement of the valency electrons around the negative ion.
Use x to represent an electron from a scandium atom.
Use o to represent an electron from a fluorine atom.



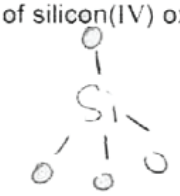
[3]

(ii) The melting point of scandium fluoride is 1552 °C. Explain why scandium fluoride has a high melting point.

Because its a giant structure. Same as Silicon(IV) oxide. [1]

(b) Silicon(IV) oxide has a macromolecular structure.

(i) Describe the structure of silicon(IV) oxide. You may use a diagram.



(IV) oxide

Silicon has a giant structure which each silicon is conected to 4 oxygens & each oxygen is conected to 2 silicons. Bonds are hard & stabk [3]

(ii) How does the electrical conductivity of these two compounds differ?

Silicon(IV) oxide has nearly 0 zero conductivity while Scandium floride has a high conductivity [1]

(iii) Explain the difference in conductivity.

It is so different & I cannot tell you => I do not know the answer [2]

[Total: 10]

Examiner comment – grade E

(a) (i) The award of marks was conditional upon a correct formula being given.

(ii) The explanation does not mention strong ionic bonds.

(b) (i) If both a diagram and an account were given the account takes precedence over the diagram. The account does not mention tetrahedral geometry so only two marks were awarded.

(ii) All that was required was that scandium fluoride conducts and silicon(IV) oxide does not, this was given in the candidate's response.

(iii) The explanation should make it clear that only the scandium fluoride has ions and these can move in the liquid phase. This is not mentioned in the candidate's comment.

Question 5

Mark scheme

5 (a) CH_3-CH_2-CH_2-CH_2-CH_2-OH [1]
88 [1]
156 to159 °C [1]

(b) any two from:
(same) general (molecular) formula
same functional group
consecutive members differ by $-CH_2$
common methods of preparation

(c) correct structure **and** 4bp around carbon [1]
2bp and 2nbp around oxygen [1]
1bp on hydrogens [1]

(d) (i) correct structural formula for propanoic acid [1]
allow: OH but all other bonds to be shown

(ii) air / oxygen [1]
bacteria / microbes / micro-organisms [1]
accept: mother of vinegar
not: yeast

(e) propyl ethanoate [1]
allow: $CH_3COOC_3H_7$ **not:** $C_5H_{10}O_2$ [1]

Example candidate response – grade A

5 The alcohols form a homologous series. Two characteristics of a homologous series are that the physical properties of the members vary in a predictable way and they have similar chemical properties.

(a) Complete the table.

name	formula	mass of one mole / g	boiling point / °C
methanol	CH_3-OH	32	64
ethanol	CH_3-CH_2-OH	46	78
propan-1-ol	$CH_3-CH_2-CH_2-OH$	60	98
butan-1-ol	$CH_3-CH_2-CH_2-CH_2-OH$	74	118
pentan-1-ol	$CH_3-CH_2-CH_2-CH_2-CH_2-OH$	88	138
hexan-1-ol	$CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-OH$	102	158

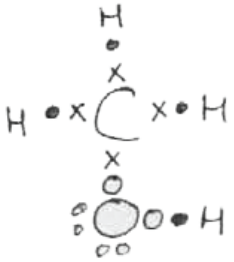
[3]

(b) Give **two** other characteristics of a homologous series.

1) They differ by CH_2.

2) They belong to the same family. [2]

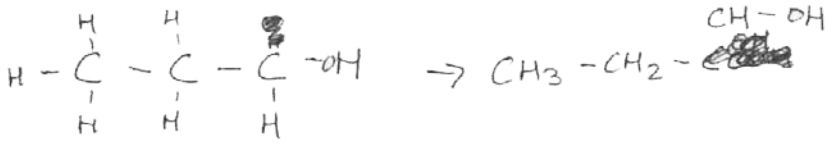
(c) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound methanol.
Use x to represent an electron from a carbon atom.
Use o to represent an electron from an oxygen atom.
Use • to represent an electron from a hydrogen atom.



[3]

(d) Alcohols can be oxidised to carboxylic acids by heating with acidic potassium manganate(VII).

(i) Draw the structural formula of the carboxylic acid formed by the oxidation of propan-1-ol. Show all the bonds.



[1]

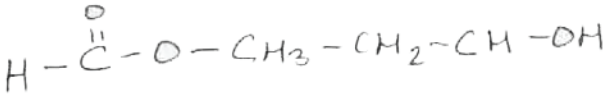
(ii) Describe how ethanol could be oxidised to ethanoic acid by fermentation.

This can be done by the anaerobic respiration of yeast where ethanoic acid and carbon dioxide is produced [2]

(e) Propan-1-ol and ethanoic acid react together to form an ester. Give its name and structural formula.

name Propyl ethanoate [1]

formula



[1]

[Total: 13]

Examiner comment – grade A

(a) The table was completed correctly. The insertions being:
$CH_3–CH_2–CH_2–CH_2–CH_2–OH$
88 mole/g
158°C

(b) The comment that they belong to the same family is not sufficient.
Suitable characteristics are:
same functional group
same general formula
common methods of preparation

(c) A correct diagram clearly presented.

(d) **(i)** Both formulae are incorrect versions of a propanol rather than a carboxylic acid. The correct formula of the oxidation product is $CH_3–CH_2–COOH$.

(ii) The conversation of ethanol to ethanoic acid is an aerobic reaction. It is the oxidation of ethanol by oxygen in the presence of bacteria.

(e) The name of the ester is correct (propyl ethanoate) but the formula is incorrect. The correct formula is of the type:

$CH_3–COOCH_2–CH_2–CH_3$

Example candidate response – grade C

5 The alcohols form a homologous series. Two characteristics of a homologous series are that the physical properties of the members vary in a predictable way and they have similar chemical properties.

(a) Complete the table.

name	formula	mass of one mole / g	boiling point / °C
methanol	$CH_3–OH$	32	64
ethanol	$CH_3–CH_2–OH$	46	78
propan-1-ol	$CH_3–CH_2–CH_2–OH$	60	98
butan-1-ol	$CH_3–CH_2–CH_2–CH_2–OH$	74	118
pentan-1-ol	$CH_3–CH_2–CH_2–CH_2–CH_2–OH$	88	138
hexan-1-ol	$CH_3–CH_2–CH_2–CH_2–CH_2–CH_2–OH$	102	158

[3]

(b) Give **two** other characteristics of a homologous series.

similar properties, same structural formulae

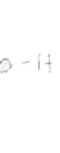
.....

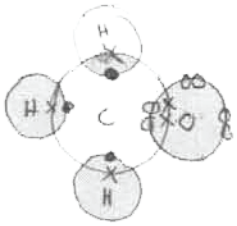
.....

[2]

(c) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound methanol.
Use x to represent an electron from a carbon atom.
Use o to represent an electron from an oxygen atom.
Use • to represent an electron from a hydrogen atom.

$C_nH_{2n+1}OH$



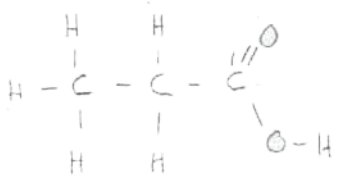


[3]

(d) Alcohols can be oxidised to carboxylic acids by heating with acidic potassium manganate(VII).

(i) Draw the structural formula of the carboxylic acid formed by the oxidation of propan-1-ol. Show all the bonds.

$C_nH_{2n+1}COOH$



[1]

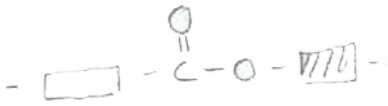
(ii) Describe how ethanol could be oxidised to ethanoic acid by fermentation.

ethanol + oxygen → ethanoic acid by fermentation. have the ethanol exposed to oxygen. this will react with the carbon forming C=O [2]

(e) Propan-1-ol and ethanoic acid react together to form an ester. Give its name and structural formula.

name propyl ethanoate [1]

formula



[1]

[Total: 13]

Examiner comment – grade C

(a) The table was completed correctly. The insertions being:
$CH_3–CH_2–CH_2–CH_2–CH_2–OH$
88 mole/g
158°C

(b) Chemical and physical properties are mentioned in the question. Members of a homologous series do not have the same structural formula. Neither comment was awarded a mark. A list of acceptable characteristics is given above.

(c) The formula of methanol is wrong, a hydrogen atom is missing. The award of marks is conditional on the formula for methanol being correct.

(d) (i) The formula of propanoic acid was accepted as correct, the 'odd' lines on the carbon of the carboxyl group were ignored.

(ii) The description included oxygen which is the oxidant, but it did not mention the presence of bacteria.

(e) The name of the ester is correct (propyl ethanoate), but the formula is incorrect. It appears to be a section of a polyester. The correct formula is of the type:
$CH_3–COOCH_2–CH_2–CH_3$.

Example candidate response – grade E

5 The alcohols form a homologous series. Two characteristics of a homologous series are that the physical properties of the members vary in a predictable way and they have similar chemical properties.

(a) Complete the table.

name	formula	mass of one mole / g	boiling point / °C
methanol	$CH_3–OH$	32	64
ethanol	$CH_3–CH_2–OH$	46	78
propan-1-o	$CH_3–CH_2–CH_2–OH$	60	98
butan-1-ol	$CH_3–CH_2–CH_2–CH_2–OH$	74	118
pentan-1-ol	$CH_3–CH_2–CH_2–CH_2–CH_2–OH$	88	138
hexan-1-ol	$CH_3–CH_2–CH_2–CH_2–CH_2–CH_2–OH$	102	158

[3]

(b) Give **two** other characteristics of a homologous series.

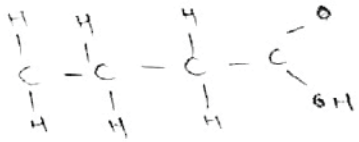
They have the same functional group and they are all alcohols. They have the same general formula [2]

(c) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound methanol.
Use x to represent an electron from a carbon atom.
Use o to represent an electron from an oxygen atom.
Use • to represent an electron from a hydrogen atom.

[3]

(d) Alcohols can be oxidised to carboxylic acids by heating with acidic potassium manganate(VII).

(i) Draw the structural formula of the carboxylic acid formed by the oxidation of propan-1-ol. Show all the bonds.



[1]

(ii) Describe how ethanol could be oxidised to ethanoic acid by fermentation.

By adding oxygen to allow combustion

[2]

(e) Propan-1-ol and ethanoic acid react together to form an ester. Give its name and structural formula.

name ethanoate [1]

formula $C_nH_{2n}CO_2H$

[1]

[Total: 13]

Examiner comment – grade E

(a) The table was completed correctly. The insertions being:
$CH_3–CH_2–CH_2–CH_2–CH_2–OH$
88 mole/g
158°C

(b) Two correct characteristics are given the same functional group and the same general formula.

(c) The formula of methanol is completely wrong, no marks could be awarded.

(d) **(i)** The formula given is closer to butanoic acid than propanoic acid, a hydrogen atom is missing and there should be a double bond between the carbon and the oxygen atoms.

(ii) Adding oxygen would normally be awarded a mark but this correct comment is negated by the suggestion that it is for the combustion, rather than the oxidation, of ethanol.

(e) The name of the ester is propyl ethanoate and its formula is of the type:
$CH_3–COOCH_2–CH_2–CH_3$

Question 6

Mark scheme

6 (a) (i) to neutralise all the acid / so all acid reacts [1]
not: reaction goes to completion

(ii) remove excess carbonate / removes unreacted carbonate [1]
not: remove solid

(iii) need water of crystallisation / hydrated crystals / to get crystals [1]

(iv) filter / decant / wash crystals [1]
dry with filter paper or tissues etc. [1]
accept: in warm oven / warm place / in sun
not: just heat

(b) (i) potassium carbonate is soluble / both salts soluble [1]

(ii) use potassium carbonate solution [1]
accept: implication of solution – in pipette / burette / 25 cm^3
titrate / titration term required [1]
use an indicator **accept:** any named acid/base indicator [1]
repeat without indicator / use carbon to remove indicator [1]

(c) mass of hydrated magnesium sulfate = 1.476 g
mass of barium sulfate formed = 1.398 g
the mass of one mole of $BaSO_4$ = 233 g
the number of moles of $BaSO_4$ formed = 0.006 [1]
the number of moles of $MgSO_4.xH_2O$ used in experiment = 0.006 [1]
the mass of one mole of $MgSO_4.xH_2O$ = 1.476/0.006 = 246 g [1]
the mass of xH_2O in one mole of $MgSO_4.xH_2O$ = 246 – 120 = 126 g [1]
x = 126/18 = 7 [1]
if x given without method = max 1
note: apply ecf but x must be an integer and less than 10

Example candidate response – grade A

6 Soluble salts can be made by the neutralisation of an acid by a base. Insoluble salts can be made by precipitation.

(a) The following is a brief description of the preparation of the soluble salt, nickel(II) chloride-6-water, from the insoluble base nickel(II) carbonate.

Nickel(II) carbonate is added in small amounts to hot dilute hydrochloric acid until it is in excess. The mixture is filtered. The filtrate is partially evaporated and then allowed to cool until crystals of nickel(II) chloride-6-water form.

(i) Why is it necessary to use excess carbonate?

To ensure that all of the hydrochloric acid reacted. [1]

(ii) Explain why it is necessary to filter.

To when all of the acid has reacted the chloral radicals [1]

(iii) Why partially evaporate rather than evaporate to dryness?

To obtain the ~~dd~~ crystallisation water and not making it a powder. [1]

(iv) What additional steps are needed to obtain dry crystals?

Squirt the crystals with distilled water and then dry the crystals between sheets of filter paper. [2]

(b) Potassium chloride can be made from hydrochloric acid and potassium carbonate.

(i) Why must a different experimental method be used for this preparation?

This is because potassium is soluble as a carbonate. [1]

(ii) Give a description of the different method used for this salt preparation.

Titration is used. Hydrochloric acid is titrated against the carbonate using a burette. A few drops of methyl orange are used to indicate the endpoint of reaction. The experiment is repeated without the indicator but with values found when the indicator was being used. The mixture is the potially evaporated and allowed to cool until crystals are formed. [4]

(c) Insoluble salts are made by precipitation. An equation for the preparation of barium sulfate is given below.

$$BaCl_2(aq) + MgSO_4(aq) \rightarrow BaSO_4(s) + MgCl_2(aq)$$

This reaction can be used to find x in the formula for hydrated magnesium sulfate $MgSO_4.xH_2O$.

A known mass of hydrated magnesium sulfate, $MgSO_4.xH_2O$, was dissolved in water. Excess aqueous barium chloride was added. The precipitate of barium sulfate was filtered, washed and dried. Finally it was weighed.

Mass of hydrated magnesium sulfate = 1.476 g

Mass of barium sulfate formed = 1.398 g

The mass of one mole of $BaSO_4$ = 233 g

The number of moles of $BaSO_4$ formed = 0.006 [1]

The number of moles of $MgSO_4.xH_2O$ = 0.006 [1]

The mass of one mole of $MgSO_4.xH_2O$ = 0.009 g [1]

The mass of one mole of $MgSO_4$ = 120 g

The mass of xH_2O in one mole of $MgSO_4.xH_2O$ = 0.006 [1]

x = 5 [1]

[Total: 15]

Examiner comment – grade A

(a) (i) The candidate's explanation is correct that is to ensure that all the hydrochloric acid is neutralised.

(ii) The meaning of this comment is not clear. The mixture is filtered to remove excess nickel(II) carbonate.

(iii) It was realised that some water must be left to form hydrated crystals and not leave the anhydrous powder.

(iv) Wash the crystals, one mark, then dry between filter paper, second mark.

(b) (i) The correct reason is given, potassium carbonate is a soluble base.

(ii) The only omission in the account is that it does not state that potassium carbonate is in solution.

(c) The number of moles of $MgSO_4 \times H_2O$ was found to be 0.006.
Two marks awarded.
*Mass of one mole of $MgSO_4 \times H_2O$ = 1.476/0.006 = 246 g
*Mass of water that is $\times H_2O$ = 246 – 120 = 126
*x = 126/18 = 7
*indicates the missing three marks.

Example candidate response – grade C

6 Soluble salts can be made by the neutralisation of an acid by a base. Insoluble salts can be made by precipitation.

(a) The following is a brief description of the preparation of the soluble salt, nickel(II) chloride-6-water, from the insoluble base nickel(II) carbonate.

Nickel(II) carbonate is added in small amounts to hot dilute hydrochloric acid until it is in excess. The mixture is filtered. The filtrate is partially evaporated and then allowed to cool until crystals of nickel(II) chloride-6-water form.

(i) Why is it necessary to use excess carbonate?

To Maintain the rate of reactivity and make the salt soluble. [1]

(ii) Explain why it is necessary to filter.

To remove the excess Carbonate [1]

(iii) Why partially evaporate rather than evaporate to dryness? anhydrous

It later becomes ~~anhydrous~~ by losing waters and becomes insoluble [1]

(iv) What additional steps are needed to obtain dry crystals?

Temperature is kept Constant [2]

(b) Potassium chloride can be made from hydrochloric acid and potassium carbonate.

(i) Why must a different experimental method be used for this preparation?

It is a mixture of a base and acid involving titration. [1]

(ii) Give a description of the different method used for this salt preparation.

The ~~HCl~~ Potassium Carbonate is taken in a Conical flask And the K Potassium Carbonate HCl is ~~is made soluble in waters and~~ taken in a burette. The indicator is added. The acid is added drop by drop until the salt has formed shown by the indicator. Keep shaking the flask until the salt and water is formed. [4]

(c) Insoluble salts are made by precipitation. An equation for the preparation of barium sulfate is given below.

$$BaCl_2(aq) + MgSO_4(aq) \rightarrow BaSO_4(s) + MgCl_2(aq)$$

This reaction can be used to find x in the formula for hydrated magnesium sulfate $MgSO_4.xH_2O$.

A known mass of hydrated magnesium sulfate, $MgSO_4.xH_2O$, was dissolved in water. Excess aqueous barium chloride was added. The precipitate of barium sulfate was filtered, washed and dried. Finally it was weighed.

Mass of hydrated magnesium sulfate = 1.476 g

Mass of barium sulfate formed = 1.398 g

The mass of one mole of $BaSO_4$ = 233 g

0·006 → The number of moles of $BaSO_4$ formed = 6×10^{-3} [1]

The number of moles of $MgSO_4.xH_2O$ = 0·006 [1]

The mass of one mole of $MgSO_4.xH_2O$ = 246 g [1]

The mass of one mole of $MgSO_4$ = 120 g

The mass of xH_2O in one mole of $MgSO_4.xH_2O$ = 126 [1]

x = 7 [1]

[Total: 15]

0·006
0·0123
0·006
246 gm
126

Examiner comment – grade C

(a) (i) The reason is nothing to do with the rate of reactivity but to neutralise all the acid.

(ii) The correct explanation is given that is to remove unreacted carbonate.

(iii) Although awarded the mark, the explanation is a bit borderline. A better explanation is: some water must be left to form hydrated crystals and not leave an anhydrous powder.

(iv) The marks are awarded for wash the crystals and dry between filter paper.

(b) (i) The reason for the different method is that potassium carbonate is a soluble base.

(ii) The candidate had the correct idea but the account was lacking in detail. It ought to have mentioned the following points:

- titration
- potassium carbonate solution
- use an indicator
- repeat without the indicator

(c) An excellent answer to quite a challenging calculation.

Example candidate response – grade E

6 Soluble salts can be made by the neutralisation of an acid by a base. Insoluble salts can be made by precipitation.

(a) The following is a brief description of the preparation of the soluble salt, nickel(II) chloride-6-water, from the insoluble base nickel(II) carbonate.

Nickel(II) carbonate is added in small amounts to hot dilute hydrochloric acid until it is in excess. The mixture is filtered. The filtrate is partially evaporated and then allowed to cool until crystals of nickel(II) chloride-6-water form.

(i) Why is it necessary to use excess carbonate?

To ensure thats HCl has be used up [1]

(ii) Explain why it is necessary to filter.

to remove excess carbonate. [1]

(iii) Why partially evaporate rather than evaporate to dryness?

if is it is ~~evaporate~~ evaporated to dryness it will not become saturated [1]

(iv) What additional steps are needed to obtain dry crystals?

They would be dried with dry filter paper. [2]

(b) Potassium chloride can be made from hydrochloric acid and potassium carbonate.

(i) Why must a different experimental method be used for this preparation?

The

[1]

(ii) Give a description of the different method used for this salt preparation.

Potassium chloride would be put in a clean conical flask and HCl in a burete. a few drops of HCl would be put in the conical flask and the gas would be collected. [4]

(c) Insoluble salts are made by precipitation. An equation for the preparation of barium sulfate is given below.

$$BaCl_2(aq) + MgSO_4(aq) \rightarrow BaSO_4(s) + MgCl_2(aq)$$

This reaction can be used to find x in the formula for hydrated magnesium sulfate $MgSO_4.xH_2O$.

A known mass of hydrated magnesium sulfate, $MgSO_4.xH_2O$, was dissolved in water. Excess aqueous barium chloride was added. The precipitate of barium sulfate was filtered, washed and dried. Finally it was weighed:

Mass of hydrated magnesium sulfate = 1.476 g

Mass of barium sulfate formed = 1.398 g

The mass of one mole of $BaSO_4$ = 233 g

The number of moles of $BaSO_4$ formed = ...6.7.... [1]

The number of moles of $MgSO_4.xH_2O$ = ...a..... [1]

The mass of one mole of $MgSO_4.xH_2O$ = ...g [1]

The mass of one mole of $MgSO_4$ = 120 g

The mass of xH_2O in one mole of $MgSO_4.xH_2O$ = ... [1]

x = ... [1]

[Total: 15]

Examiner comment – grade E

(a) (i) The candidate's explanation is correct.

(ii) Another correct explanation.

(iii) The candidate's explanation is meaningless in the context of the question. Some water must be left to form hydrated crystals and not leave an anhydrous powder.

(iv) The second mark was given for filter off the crystals or wash them.

(b) (i) This does not constitute an attempt at answering the question. The reason why a different method has to be used is that potassium carbonate is a soluble base whereas nickel(II) carbonate is insoluble.

(ii) The method described does not address the required preparation. The reagent is stated to be potassium chloride not potassium carbonate. The reaction between a carbonate and an acid will produce the gas, carbon dioxide, but there is no reason why this should be collected. Details of this salt preparation are given in the grade C example candidate response.

(c) This is not a serious attempt to complete this calculation. The correct solution is given in the grade C example candidate response.

Question 7

Mark scheme

7 **(a)** fraction is the distillate collected [1]
between 40–100 °C / in the stated range [1]

(b) **(i)** $C_8H_{18} + 25/2O_2 \rightarrow 8CO_2 + 9H_2O$ [2]
accept: double the above / 12.5 in front of oxygen

(ii) poisonous / toxic / damages health / brain / kidneys [1]
note: must relate to people
not: just harmful

(iii) dibromo 2 bromine atoms (per molecule)
not: Br_2
accept: 2 bromide groups
eth 2 carbon atoms (per molecule)
ane a C-C single bond / no C=C / group C_nH_{2n+1} / saturated
ignore: any reference to alkanes
all three correct [2] two correct only [1] [2]

(iv) position of bromine atom(s) [1]

(c) 0.104/0.026 [1]
n = 4 [1]

(d) (oxides of nitrogen) change carbon monoxide into carbon dioxide [1]
oxides of nitrogen then become nitrogen [1]
(oxides of nitrogen) change hydrocarbons into carbon dioxide and water [1]
accept: balanced equations for first two marks
$2NO + 2CO \rightarrow N_2 + 2CO_2$ **and** $2NO \rightarrow N_2 + O_2$ [2]
oxygen changes hydrocarbons into carbon dioxide and water [1]

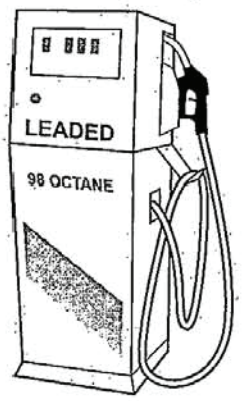
Example candidate response – grade A

7 Petrol is a mixture of hydrocarbons and additives. The combustion of petrol in car engines is a major source of air pollution. This is reduced by catalytic converters.

(a) Petrol is obtained from the gasoline fraction, boiling point range 40 °C to 100 °C, from the distillation of petroleum. Explain the term *fraction*.

a ~~part of~~ liquid (substance) obtained from fractional distillation of (crude oil) at a certain temperature. [2]

(b) In many countries, a lead compound of the type $Pb(C_2H_5)_n$ used to be added to petrol to improve its combustion. After combustion, lead oxide was formed.



(i) Octane is a constituent of petrol. Write the equation for the complete combustion of octane.

C_8H_{18} + ... $9O_2$ → $8CO_2$ + $9H_2O$ [2]

(ii) Dibromoethane was added to petrol to remove the lead oxide from inside the engine. Lead bromide was formed which escaped into the environment through the exhaust. Leaded petrol cannot be used with a catalytic converter. Give another reason why leaded petrol is no longer used.

Lead is harmful to humans [1]

(iii) What does each of the following tell you about the structure of dibromoethane? (C_2H_5OH)

dibromo 2 bromine atoms in it.

eth 2 carbon atoms in it.

ane It is an alkane [2]

(iv) What additional information is needed to draw the structural formula of dibromoethane?

The position of isomers e.g. dibromo-1-ethane. [1]

(c) An analysis of the compound, $Pb(C_2H_5)_n$, showed that 0.026 moles of Pb was combined with 0.104 moles of C_2H_5 groups.
What is the value of n? Show how you arrived at your answer.

$Pb(C_2H_5)_n \rightarrow C_2H_5$

$0,026\ (C_2H_5)n \rightarrow 0,104\ C_2H_5$ $\quad n = \frac{0,104}{0,026} = 4$ [2]

(d) Some of the pollutants emitted by vehicle exhausts are carbon monoxide, oxides of nitrogen and unburnt hydrocarbons. Explain how the emission of these gases is reduced by a catalytic converter.

A catalytic converter oxidises carbon monoxide to carbon dioxide and reduces nitrogen oxides to nitrogen and releases them in the atmosphere. [3]

[Total: 13]

Examiner comment – grade A

(a) Fraction is the distillate collected in a specified boiling point range.

(b) (i) The equation for the complete combustion of octane is:
$C_8H_{18} + 12.5\ O_2 \rightarrow 8CO_2 + 9H_2O$
or $2C_8H_{18} + 25\ O_2 \rightarrow 16CO_2 + 18H_2O$
The only error in the equation on the script was the balancing of the oxygen atoms. One mark was awarded.

(ii) Provided the comment referred to, or implied human health, it was accepted. The usual effects of lead poisoning include learning and behavioural problems in children and toxicity to many organs. A precise medical condition was not required just harmful to health would suffice.

(iii) Only two out of three comments are correct, so one mark not two was awarded.
The ending ane indicates that the compound does not contain a C=C bond, not that it is an alkane.

(iv) The additional information needed is the positions of the bromine atoms in the molecule of dibromoethane. This is probably what the candidate meant to convey but failed to do so.

(c) The calculation is correct. n = moles of C_2H_5/moles of Pb. So n = 4.

(d) The oxides of nitrogen are converted into nitrogen. They oxidise carbon monoxide to carbon dioxide:
$2CO + 2NO \rightarrow 2CO_2 + N_2$
The explanation does not include that the unburnt hydrocarbons are oxidised by the oxides of nitrogen to carbon dioxide and water. Only two marks could be awarded.

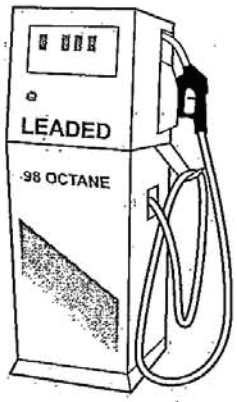
Example candidate response – grade C

7 Petrol is a mixture of hydrocarbons and additives. The combustion of petrol in car engines is a major source of air pollution. This is reduced by catalytic converters.

(a) Petrol is obtained from the gasoline fraction, boiling point range 40 °C to 100 °C, from the distillation of petroleum. Explain the term *fraction*.

It is made from gasoline, and it's one of the product of gasoline. [2]

(b) In many countries, a lead compound of the type $Pb(C_2H_5)_n$ used to be added to petrol to improve its combustion. After combustion, lead oxide was formed.



(i) Octane is a constituent of petrol. Write the equation for the complete combustion of octane.

$C_8H_{18} + 12.5\ O_2 \rightarrow 8\ CO_2 + 9\ H_2O$ [2]

(ii) Dibromoethane was added to petrol to remove the lead oxide from inside the engine. Lead bromide was formed which escaped into the environment through the exhaust. Leaded petrol cannot be used with a catalytic converter. Give another reason why leaded petrol is no longer used.

Leaded petrol is dangerous. [1]

(iii) What does each of the following tell you about the structure of dibromoethane?

dibromo there are 2 bromine

eth 2 carbon structure

ane it is an alkane [2]

(iv) What additional information is needed to draw the structural formula of dibromoethane?

The other product formed. [1]

(c) An analysis of the compound, $Pb(C_2H_5)_n$, showed that 0.026 moles of Pb was combined with 0.104 moles of C_2H_5 groups.
What is the value of n? Show how you arrived at your answer.

$(0.026 + 0.104n = 207 + 2 \times 12 + 5 \times 1$

$0.13n$ ~~$0.124n$~~ ~~$0.026 + 0.104n$~~ $= 236$ ∴ $n =$ ~~1903~~ 1815

[2]

(d) Some of the pollutants emitted by vehicle exhausts are carbon monoxide, oxides of nitrogen and unburnt hydrocarbons. Explain how the emission of these gases is reduced by a catalytic converter.

Catalytic converter converts dangerous materials into less dangerous substances with catalyst. CO will be changed to CO_2, and etc.

[3]

[Total: 13]

Examiner comment – grade C

(a) The explanation is too vague. Fraction is the distillate collected in a specified boiling range.

(b) **(i)** The correct equation is given.

(ii) The reason is too general. The usual effects of lead poisoning include learning and behavioural problems in children and toxicity to many organs. A precise medical condition was not required just harmful to health would suffice.

(iii) Two bromine atoms per molecule and two carbon atoms per molecule would have been preferable. The ending ane indicates that the compound does not contain a C=C bond, not that it is an alkane.

(iv) This is another vague and meaningless comment. The additional information needed is the positions of the bromine atoms in the molecule of dibromoethane.

(c) The correct calculation is: n = moles of C_2H_5/moles of Pb. So n = 4.

(d) The oxides of nitrogen are converted into nitrogen. They oxidise carbon monoxide to carbon dioxide:
$2CO + 2NO \rightarrow 2CO_2 + N_2$
The unburnt hydrocarbons are oxidised by the oxides of nitrogen to carbon dioxide and water. Only the mark for carbon monoxide becoming carbon dioxide could be awarded.

Example candidate response – grade E

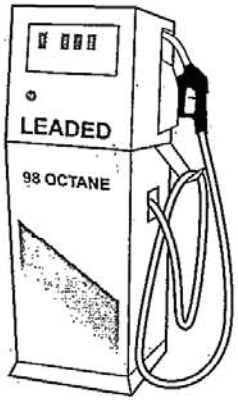
7 Petrol is a mixture of hydrocarbons and additives. The combustion of petrol in car engines is a major source of air pollution. This is reduced by catalytic converters.

(a) Petrol is obtained from the gasoline fraction, boiling point range 40 °C to 100 °C, from the distillation of petroleum. Explain the term *fraction*.

fraction is part of a whole

..... [2]

(b) In many countries, a lead compound of the type $Pb(C_2H_5)_n$ used to be added to petrol to improve its combustion. After combustion, lead oxide was formed.



(i) Octane is a constituent of petrol. Write the equation for the complete combustion of octane.

2x = 25 C_8H_{18} + ...12.5O_2 → 8CO_2 .... + 9H_2O ..25 [2]

(ii) Dibromoethane was added to petrol to remove the lead oxide from inside the engine. Lead bromide was formed which escaped into the environment through the exhaust. Leaded petrol cannot be used with a catalytic converter. Give another reason why leaded petrol is no longer used.

It is a big pollutant [1]

(iii) What does each of the following tell you about the structure of dibromoethane?

dibromo has a ~~brane~~ branch

eth 2 carbon atoms

ane its an alkane [2]

(iv) What additional information is needed to draw the structural formula of dibromoethane?

nothing [1]

(c) An analysis of the compound, $Pb(C_2H_5)_n$, showed that 0.026 moles of Pb was combined with 0.104 moles of C_2H_5 groups.
What is the value of n? Show how you arrived at your answer.

$\frac{n}{mr}$ $\frac{0,026}{0,104}$

$=0,25$

[2]

(d) Some of the pollutants emitted by vehicle exhausts are carbon monoxide, oxides of nitrogen and unburnt hydrocarbons. Explain how the emission of these gases is reduced by a catalytic converter.

catalyst reduce pollutants and react quickly to reduce pollutio

[3]

[Total: 13]

Examiner comment – grade E

(a) The explanation of the term fraction is given in a mathematical context rather than a chemical one. A fraction is the distillate collected in a specified boiling point range.

(b) (i) A correct equation is given.

(ii) Just stating that lead compounds are pollutants is stating the obvious. The usual effects of lead poisoning include learning and behavioural problems in children and toxicity to many organs. A precise medical condition was not required; harmful to human health would be awarded the mark.

(iii) None of the three comments is correct. Two bromine atoms per molecule and two carbon atoms per molecule are needed for comments 1 and 2. The ending -ane indicates that the compound does not contain a C=C bond, not that it is an alkane.

(iv) The additional information needed is the positions of the bromine atoms in the molecule of dibromoethane.

(c) The candidate has determined the reciprocal of n.
n = moles of C_2H_5/moles of Pb. So n = 4.

(d) The comment is based on the knowledge that a catalyst increases reaction rate and the information given in the question. It does not explain the Chemistry of a catalytic converter.

Paper 5 – Practical test

Paper 5 is the Practical Test which covers experimental and observational skills. The purpose of this component is to test appropriate skills in assessment objective C (Experimental skills and investigations). Candidates are not required to use knowledge outside the Core curriculum.

Question 1

Mark scheme

1 **(a)** experiment 1 all boxes completed (1)
results show a regular pattern (1) [2]

(b) experiment 2 all boxes completed (1)
results show a regular pattern (1) [2]

(c) all points correctly plotted (+/– ½ small square) (2), –1 for any incorrect
Should have a y axis:
linear scale and points extend over at least 4 big squares (8 cm) (1)
two × smooth lines (curved or straight) (2)
both lines labelled (1) [6]

(d) **(i)** value from graph (+/– ½ small square) (1) shown clearly (1) [2]

(ii) value from graph (+/– ½ small square) (1) shown clearly (1) [2]

(e) endothermic (1) [1]

(f) lower temperature (changes) (1)
greater volume/more water (1) [2]

(g) room temperature or initial temperature from table (1)
reaction finished/<u>all</u> dissolved/warms up (1) [2]

(h) more readings/points (1)
better graph/more reliable/more accurate/owtte (1) [2]

[Total: 21]

Example candidate response – grade A

1 You are going to investigate what happens when two different solids, **C** and **D**, dissolve in water.

Read all the instructions below carefully before starting the experiments.

Instructions
You are going to carry out two experiments.

(a) *Experiment 1*

Place the polystyrene cup in the 250 cm^3 beaker for support.

Use a measuring cylinder to pour 25 cm^3 of distilled water into the polystyrene cup. Measure the temperature of the water and record it in the table below.

Add all of solid **C** to the water, start the timer and stir the mixture with the thermometer.

Measure the temperature of the solution every 30 seconds for three minutes. Record your results in the table.

time / s	0	30	60	90	120	150	180
temperature of solution / °C	27	39	40	40.5	41	41	40.5

[2]

(b) *Experiment 2*

Empty the polystyrene cup and rinse it with water.

Use a measuring cylinder to pour 25 cm^3 of distilled water into the polystyrene cup. Measure the temperature of the water and record it in the table below.

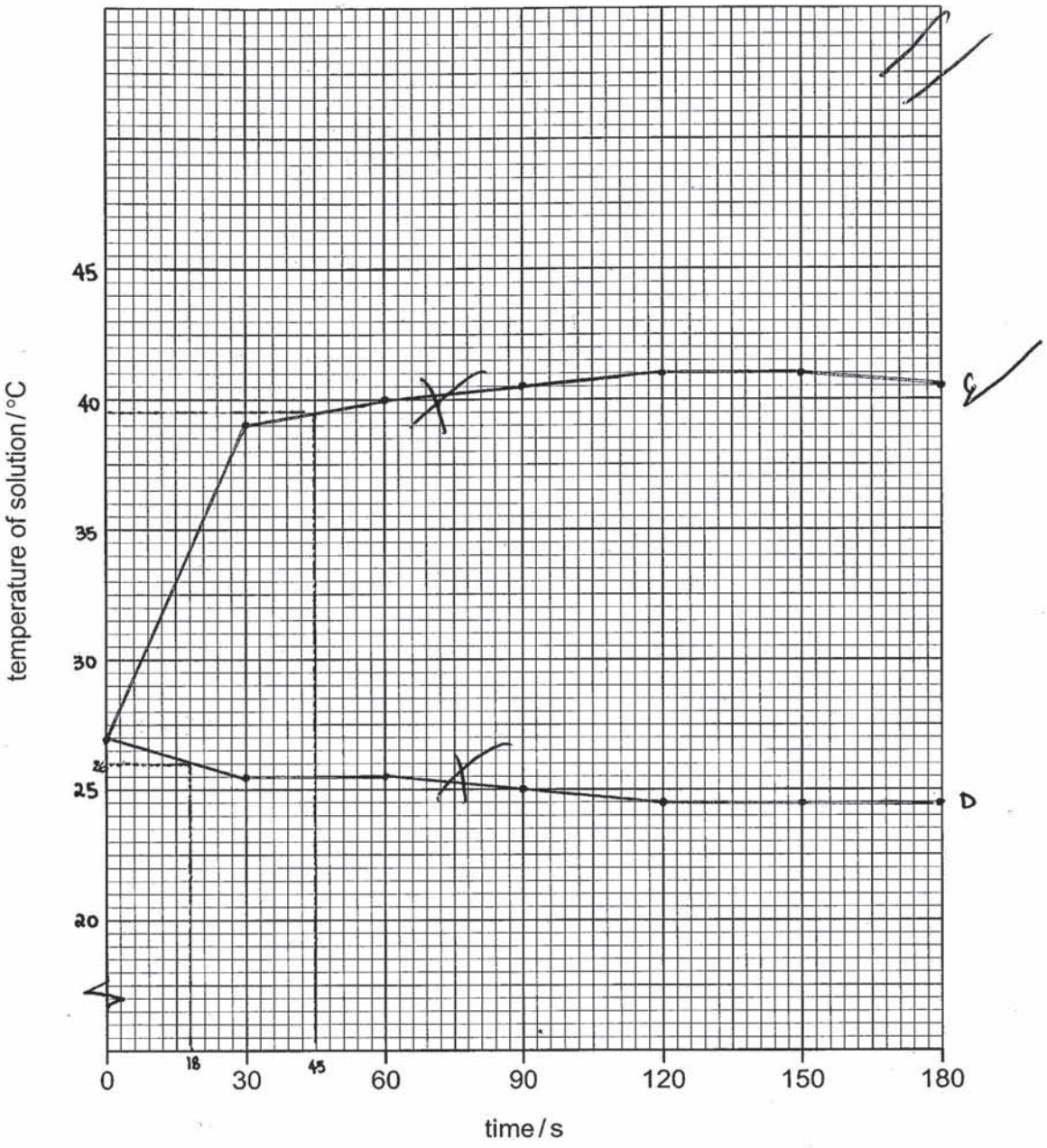
Add all of solid **D** to the water, start the timer and stir the mixture with the thermometer.

Measure the temperature of the solution every 30 seconds for three minutes. Record your results in the table.

time / s	0	30	60	90	120	150	180
temperature of solution / °C	27	25.5	25.5	25	24.5	24.5	24.5

[2]

(c) Plot the results for Experiments 1 and 2 on the grid and draw two smooth line graphs. Clearly label your graphs.



[6]

(d) **(i)** **From your graph**, deduce the temperature of the solution in Experiment 1 after 45 seconds.
Show clearly **on the graph** how you worked out your answer.

39.5 °C [2]

(ii) **From your graph**, deduce how long it takes for the **initial** temperature of the solution in Experiment 2 to change by 1 °C.
Show clearly **on the graph** how you worked out your answer.

18 s [2]

(e) What type of change occurs when substance **D** dissolves in water?

Endothermic ✓ [1]

(f) Suggest and explain the effect on the results if Experiment 1 was repeated using 50 cm^3 of distilled water.

The change in temperature would take place slower as the ratio of reactant and water would be lower. ✗ ✓ [2]

(g) Predict the temperature of the solution in Experiment 2 after 1 hour. Explain your answer.

It stays 24.5°C or below as the heat and energy is kept in the solution. ✗ [2]

(h) When carrying out the experiments, what would be the advantage of taking the temperature readings every 15 seconds?

The result would be more accurate ✓ [2]

[Total: 21]

Examiner comment – grade A

Both experiments were successfully carried out and the results' tables clearly completed. The two sets of results showed a regular pattern scoring full credit. In experiment 1, the temperatures increased and then levelled out. In experiment 2, the results showed the temperatures decreasing and then levelling out as expected.

The points were correctly plotted in **(c)**. However, the graphs drawn were not smooth lines though credit was given for labelling them. In part **(d)**, the candidate was able to use the graphs to work out the information required and scored full credit.

Example candidate response – grade A

1 You are going to investigate what happens when two different solids, **C** and **D**, dissolve in water.

Read all the instructions below carefully before starting the experiments.

Instructions
You are going to carry out two experiments.

(a) *Experiment 1*

Place the polystyrene cup in the 250 cm^3 beaker for support.

Use a measuring cylinder to pour 25 cm^3 of distilled water into the polystyrene cup. Measure the temperature of the water and record it in the table below.

Add all of solid **C** to the water, start the timer and stir the mixture with the thermometer.

Measure the temperature of the solution every 30 seconds for three minutes. Record your results in the table.

time / s	0	30	60	90	120	150	180
temperature of solution / °C	26·0	38·0	41·0	42·0	42·0	42·0	41·5

[2]

(b) *Experiment 2*

Empty the polystyrene cup and rinse it with water.

Use a measuring cylinder to pour 25 cm^3 of distilled water into the polystyrene cup. Measure the temperature of the water and record it in the table below.

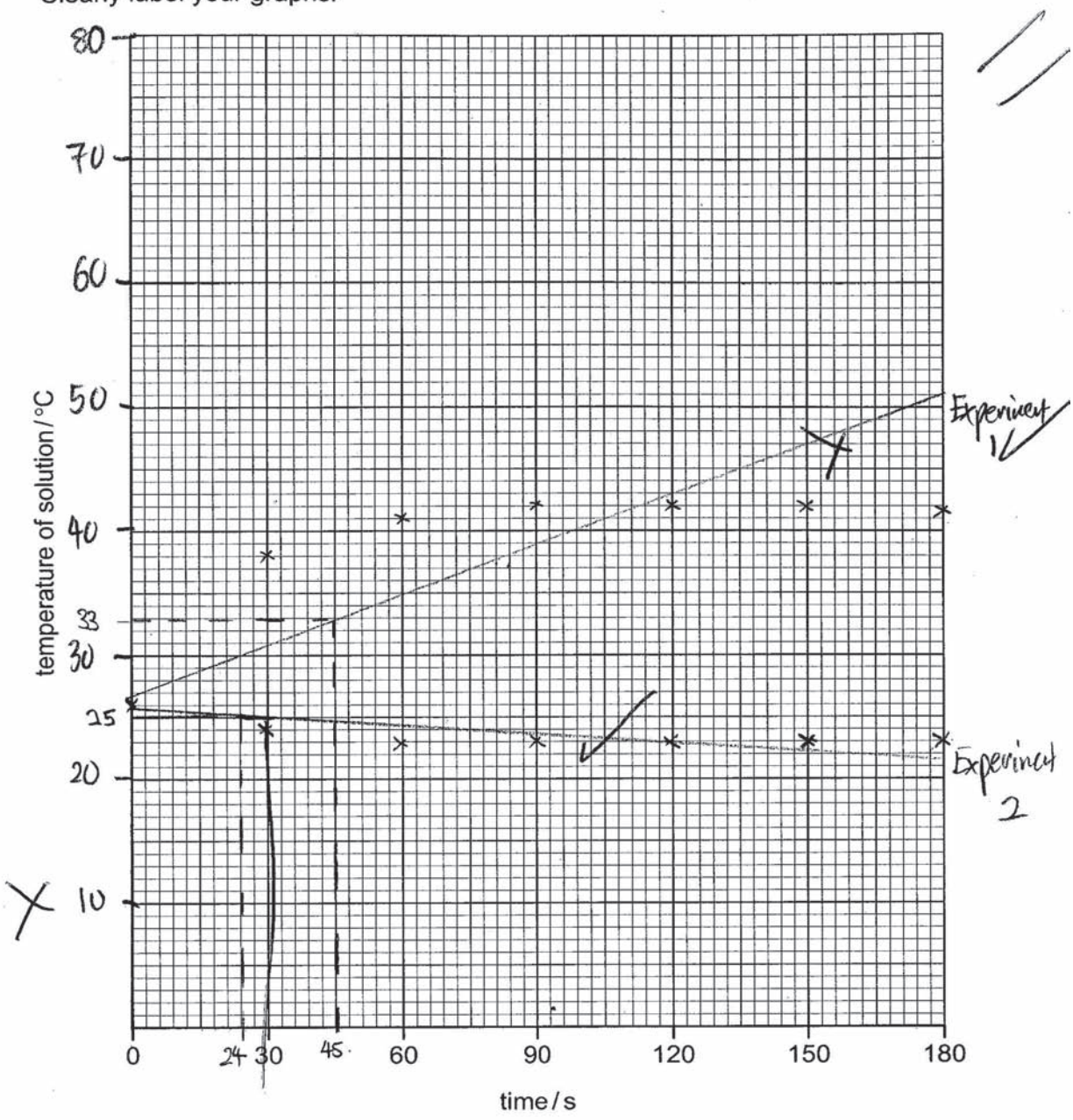
Add all of solid **D** to the water, start the timer and stir the mixture with the thermometer.

Measure the temperature of the solution every 30 seconds for three minutes. Record your results in the table.

time / s	0	30	60	90	120	150	180
temperature of solution / °C	26·0	24·0	23·0	23·0	23·0	23·0	23·0

[2]

(c) Plot the results for Experiments 1 and 2 on the grid and draw two smooth line graphs. Clearly label your graphs.



[6]

(d) (i) **From your graph**, deduce the temperature of the solution in Experiment 1 after 45 seconds.
Show clearly **on the graph** how you worked out your answer.

33 °C ✓✓

[2]

(ii) **From your graph**, deduce how long it takes for the **initial** temperature of the solution in Experiment 2 to change by 1 °C.
Show clearly **on the graph** how you worked out your answer.

24 s

[2]

(e) What type of change occurs when substance **D** dissolves in water?

An endothermic change. ✓ [1]

(f) Suggest and explain the effect on the results if Experiment 1 was repeated using 50 cm^3 of distilled water.

The temperature increase would be halved as the volume of water is doubled. This increase in volume reduces the heat energy per cm^3 and so the temperature change decreases. [2]

(g) Predict the temperature of the solution in Experiment 2 after 1 hour. Explain your answer.

The temperature would be 26°c as it would return to the initial room temperature. [2]

(h) When carrying out the experiments, what would be the advantage of taking the temperature readings every 15 seconds?

The measuring temperature at more, the intervals = frequ increases the accuracy of the results as it takes into account more of the temperature changes. [2]

[Total: 21]

Examiner comment – grade A

In part **(e)**, the endothermic change was successfully identified though this was not a discriminating question. The idea of a lower temperature change because of an increase in the volume of water was correctly described in **(f)**. The candidate realised in **(g)** that the temperature of the solution would return to room temperature but failed to explain the reason, i.e. that the reaction had finished. The candidate recognised in part **(h)** that more frequent measurements at 15 second intervals would increase the accuracy of the results.

Example candidate response – grade C

1 You are going to investigate what happens when two different solids, **C** and **D**, dissolve in water.

Read all the instructions below carefully before starting the experiments.

Instructions
You are going to carry out two experiments.

(a) *Experiment 1*

Place the polystyrene cup in the 250 cm^3 beaker for support.

Use a measuring cylinder to pour 25 cm^3 of distilled water into the polystyrene cup. Measure the temperature of the water and record it in the table below.

Add all of solid **C** to the water, start the timer and stir the mixture with the thermometer.

Measure the temperature of the solution every 30 seconds for three minutes. Record your results in the table.

time / s	0	30	60	90	120	150	180
temperature of solution / °C	27	42	44	43	42	41	40

[2]

(b) *Experiment 2*

Empty the polystyrene cup and rinse it with water.

Use a measuring cylinder to pour 25 cm^3 of distilled water into the polystyrene cup. Measure the temperature of the water and record it in the table below.

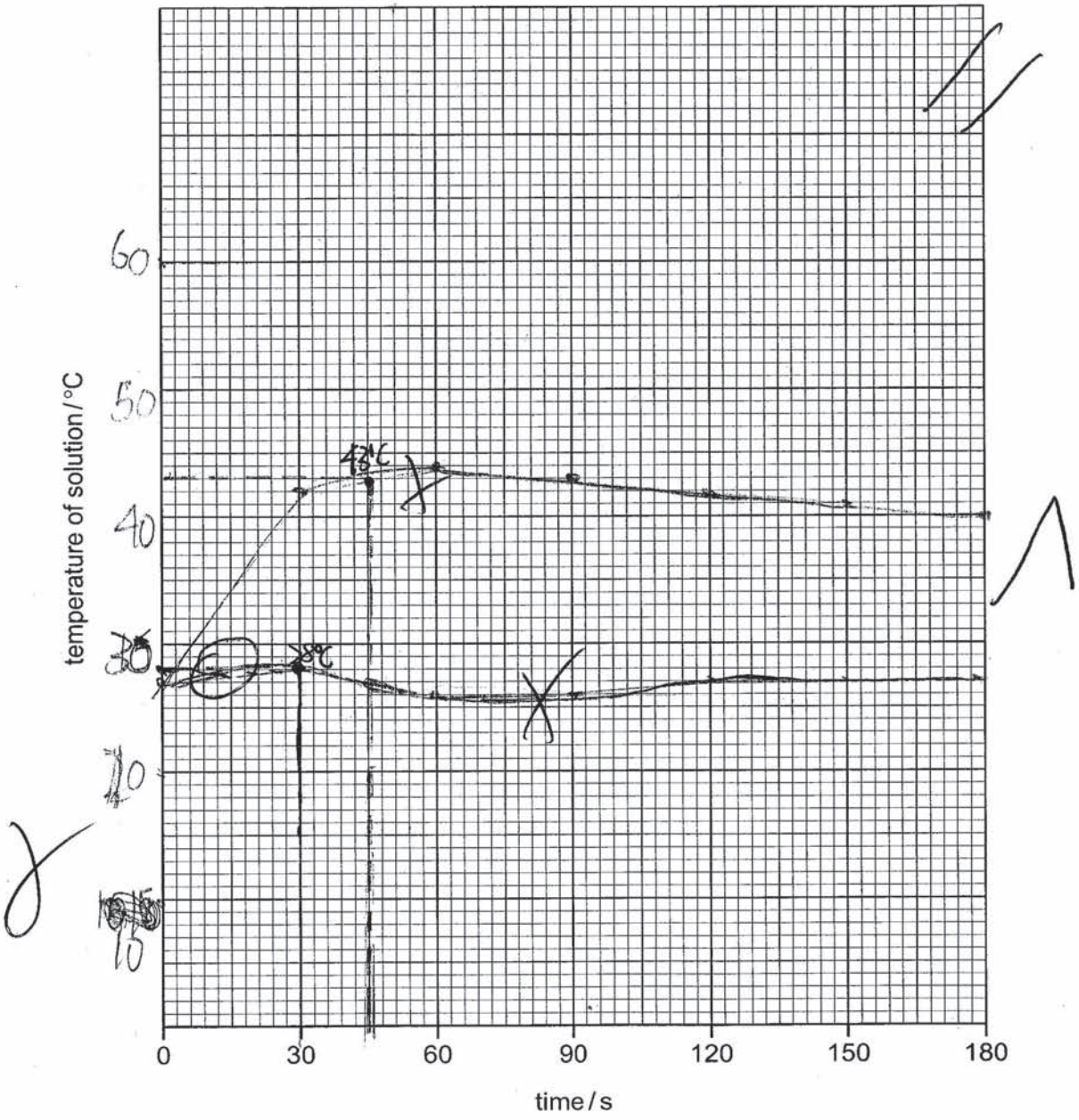
Add all of solid **D** to the water, start the timer and stir the mixture with the thermometer.

Measure the temperature of the solution every 30 seconds for three minutes. Record your results in the table.

time / s	0	30	60	90	120	150	180
temperature of solution / °C	27	28	26	26	27	27	27

[2]

(c) Plot the results for Experiments 1 and 2 on the grid and draw two smooth line graphs. Clearly label your graphs.



[6]

(d) (i) **From your graph**, deduce the temperature of the solution in Experiment 1 after 45 seconds.
Show clearly **on the graph** how you worked out your answer.

..... °C [2]

(ii) **From your graph**, deduce how long it takes for the **initial** temperature of the solution in Experiment 2 to change by 1 °C.
Show clearly **on the graph** how you worked out your answer.

..... s [2]

(e) What type of change occurs when substance **D** dissolves in water?

Endothermic, ✓ absorb heat ✓. [1]

(f) Suggest and explain the effect on the results if Experiment 1 was repeated using 50 cm^3 of distilled water.

The volume doubled, the difference between 0s and 180s temperature should be divided 2, the temperature change slowly ✓ to 33.5°C at 180s. ✓ [2]

(g) Predict the temperature of the solution in Experiment 2 after 1 hour. Explain your answer.

Unchanged ✓ the reaction finished, the solid D dissolved during ~~the~~ 3 seconds. [2]

(h) When carrying out the experiments, what would be the advantage of taking the temperature readings every 15 seconds?

~~More accurately the data is~~. The data might be more accurately. ✓ [2]

[Total: 21]

Examiner comment – grade C

The candidate carried out both experiments. Marks were awarded for completing the tables of results. However, the results for experiment **2** were credited with only one mark as they did not show a regular pattern. The temperatures show an increase then a decrease before levelling out at the same temperature as the initial reading.

The points were plotted correctly in **(c)**, but the graphs drawn were not smooth lines and were unlabelled. The scale chosen for the y axis was inappropriate as the points plotted did not extend over at least four big squares.

In part **(d)(i)**, the candidate was able to use the graph to deduce the temperature of the solution after 45 seconds. Unfortunately in **(d)(ii)**, a confused indication of the temperature showed that the graph had not been used as required.

Example candidate response – grade C

1 You are going to investigate what happens when two different solids, **C** and **D**, dissolve in water.

Read all the instructions below carefully before starting the experiments.

Instructions
You are going to carry out two experiments.

(a) *Experiment 1*

Place the polystyrene cup in the 250 cm^3 beaker for support.

Use a measuring cylinder to pour 25 cm^3 of distilled water into the polystyrene cup. Measure the temperature of the water and record it in the table below.

Add all of solid **C** to the water, start the timer and stir the mixture with the thermometer.

Measure the temperature of the solution every 30 seconds for three minutes. Record your results in the table.

time / s	0	30	60	90	120	150	180
temperature of solution / °C	29	31	32	32	32·5	32·5	32·5

[2]

(b) *Experiment 2*

Empty the polystyrene cup and rinse it with water.

Use a measuring cylinder to pour 25 cm^3 of distilled water into the polystyrene cup. Measure the temperature of the water and record it in the table below.

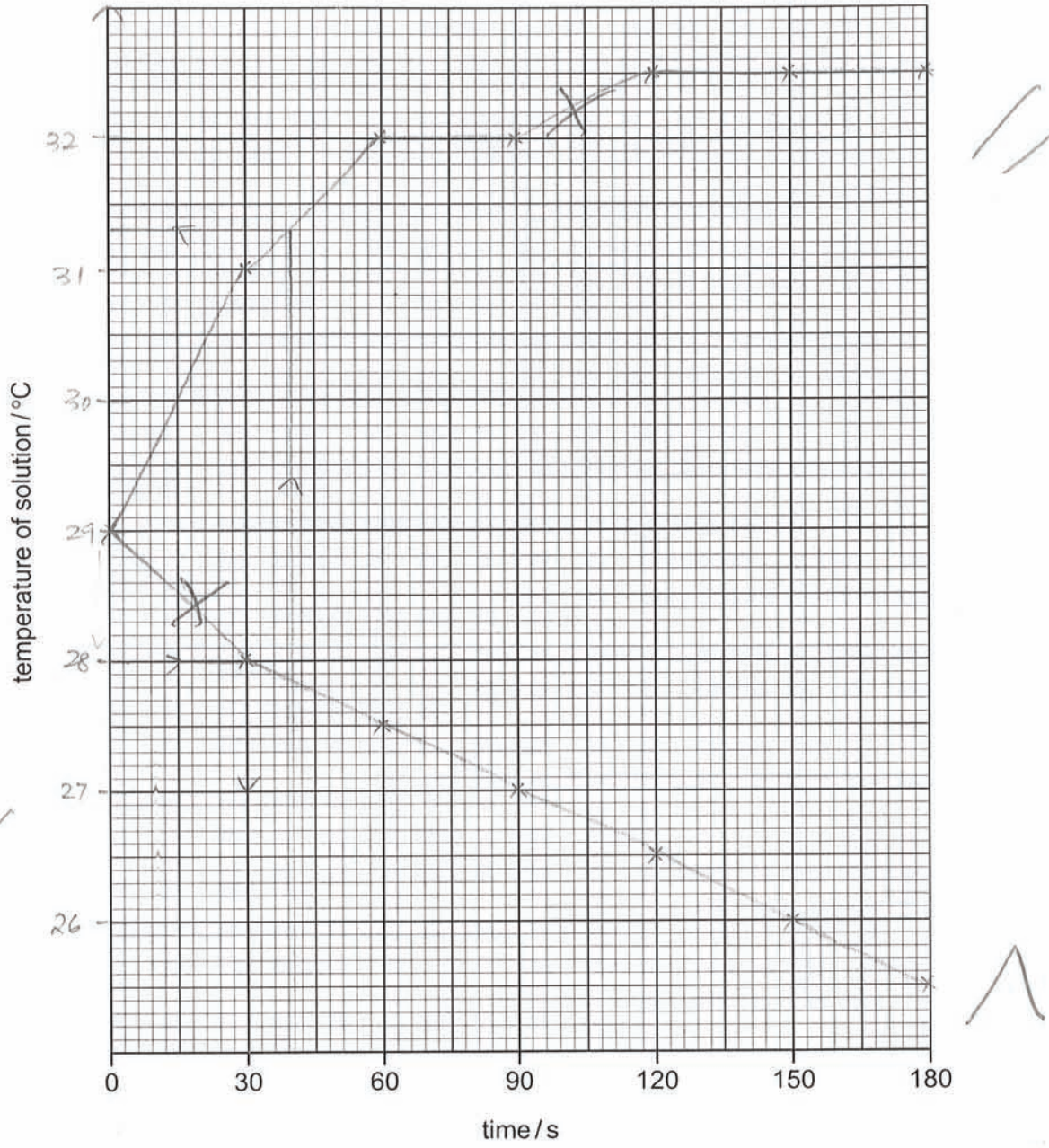
Add all of solid **D** to the water, start the timer and stir the mixture with the thermometer.

Measure the temperature of the solution every 30 seconds for three minutes. Record your results in the table.

time / s	0	30	60	90	120	150	180
temperature of solution / °C	29	28	27·5	27	26·5	26	25·5

[2]

(c) Plot the results for Experiments 1 and 2 on the grid and draw two smooth line graphs. Clearly label your graphs.



[6]

(d) **(i)** **From your graph**, deduce the temperature of the solution in Experiment 1 after 45 seconds.
Show clearly **on the graph** how you worked out your answer.

31·5 approx °C [2]

(ii) **From your graph**, deduce how long it takes for the **initial** temperature of the solution in Experiment 2 to change by 1 °C.
Show clearly **on the graph** how you worked out your answer.

30 s [2]

(e) What type of change occurs when substance **D** dissolves in water?

endothermic ✓ [1]

(f) Suggest and explain the effect on the results if Experiment 1 was repeated using 50 cm^3 of distilled water.

If repeated using 50 cm^3, the solution would become more dilute & the temp. change would not be much ✓ [2]

(g) Predict the temperature of the solution in Experiment 2 after 1 hour. Explain your answer.

The temp. would become stable at about 15°C, because at some point, the reaction would ~~slow~~ down ✓ [2]

(h) When carrying out the experiments, what would be the advantage of taking the temperature readings every 15 seconds?

Taking readings every 15 seconds gives more accurate results and if the time to record the result is a dividend of 15 ✓ ✓ [2]

[Total: 21]

Examiner comment – grade C

The candidate's answer in **(f)** received partial credit for implying a lower temperature change, ie 'the temperature change would not be much'. A lack of knowledge and understanding was evident in **(g)** with a vague reference to the temperature becoming stable. Stating that the reaction 'would slow down 'showed that the candidate did not realise that the reaction was finished and that the solution would return to room temperature. Partial credit was given for recognising that more accurate results would be obtained in **(h)**.

Example candidate response – grade E

1 You are going to investigate what happens when two different solids, **C** and **D**, dissolve in water.

Read all the instructions below carefully before starting the experiments.

Instructions
You are going to carry out two experiments.

(a) *Experiment 1*

Place the polystyrene cup in the 250 cm^3 beaker for support.

Use a measuring cylinder to pour 25 cm^3 of distilled water into the polystyrene cup. Measure the temperature of the water and record it in the table below.

Add all of solid **C** to the water, start the timer and stir the mixture with the thermometer.

Measure the temperature of the solution every 30 seconds for three minutes. Record your results in the table.

time / s	0	30	60	90	120	150	180
temperature of solution / °C	25°	30°	~~33°~~ 34°	33°	34°	34°	34°

[2]

(b) *Experiment 2*

Empty the polystyrene cup and rinse it with water.

Use a measuring cylinder to pour 25 cm^3 of distilled water into the polystyrene cup. Measure the temperature of the water and record it in the table below.

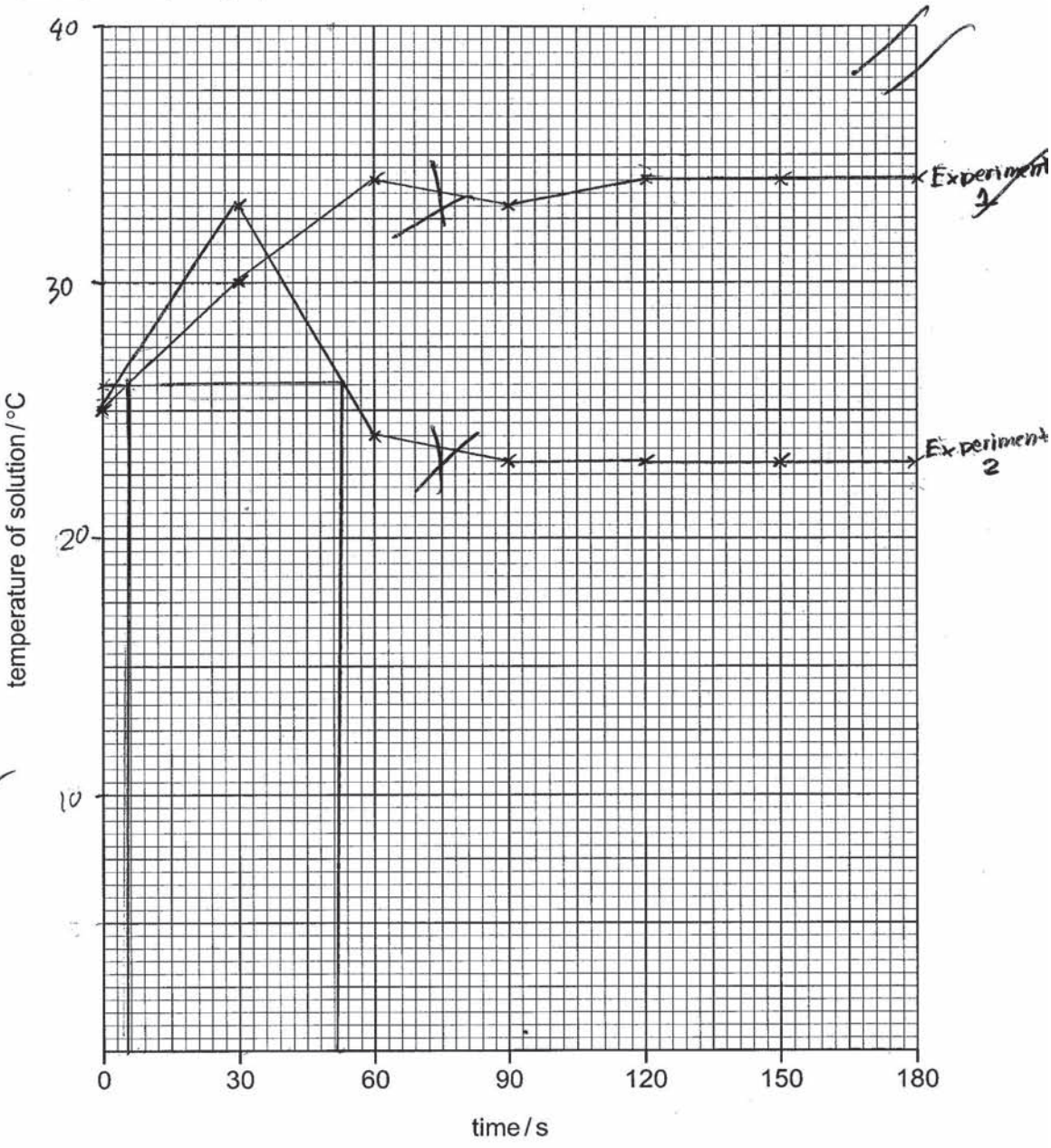
Add all of solid **D** to the water, start the timer and stir the mixture with the thermometer.

Measure the temperature of the solution every 30 seconds for three minutes. Record your results in the table.

time / s	0	30	60	90	120	150	180
temperature of solution / °C	25°	33°	~~24~~ ~~23°~~	23°	23°	23°	~~23°~~ ~~25°~~

[2]

(c) Plot the results for Experiments 1 and 2 on the grid and draw two smooth line graphs. Clearly label your graphs.



[6]

(d) (i) **From your graph**, deduce the temperature of the solution in Experiment 1 after 45 seconds.
Show clearly **on the graph** how you worked out your answer.

.....26°..... °C [2]

(ii) **From your graph**, deduce how long it takes for the **initial** temperature of the solution in Experiment 2 to change by 1 °C.
Show clearly **on the graph** how you worked out your answer.

.....10 ... 7 s [2]

(e) What type of change occurs when substance **D** dissolves in water?

~~Endothermic~~ ~~Exothermic reaction~~ Endothermic reaction [1]

(f) Suggest and explain the effect on the results if Experiment 1 was repeated using 50 cm^3 of distilled water.

The temperature would ~~increase~~ decrease because the solid ~~particles are gaining more energy to escape water would cause the particles to go slower.~~ would dissolve faster [2]

(g) Predict the temperature of the solution in Experiment 2 after 1 hour. Explain your answer.

24 °C because the ~~particles~~ temperature decreases as a result of the solid dissolving into the distilled water. [2]
very ~~quickly~~ slowly.

(h) When carrying out the experiments, what would be the advantage of taking the temperature readings every 15 seconds?

You ~~can~~ will know if any errors have been made with the apparatus and ~~so~~ solids ~~or~~ if ~~you have~~ you were to check the ~~readings~~ ~~rea~~ readings every ~~15~~ 15 seconds [2]

[Total: 21]

Examiner comment – grade E

The candidate successfully followed instructions and completed the tables of results for both experiments. Both tables of results only scored partial credit as they showed an irregular pattern with unexpected increasing temperatures followed by decreasing temperatures.

The points were plotted correctly in **(c)** but the graphs were not remotely smooth lines. The scale chosen for the y axis was inappropriate. In part **(d)**, the candidate was unable to use the graphs and process the information as required. The wrong graphs were chosen for both parts of the question and scored no credit.

Example candidate response – grade E

1 You are going to investigate what happens when two different solids, **C** and **D**, dissolve in water.

Read all the instructions below carefully before starting the experiments.

Instructions
You are going to carry out two experiments.

(a) *Experiment 1*

Place the polystyrene cup in the 250 cm^3 beaker for support.

Use a measuring cylinder to pour 25 cm^3 of distilled water into the polystyrene cup. Measure the temperature of the water and record it in the table below.

Add all of solid **C** to the water, start the timer and stir the mixture with the thermometer.

Measure the temperature of the solution every 30 seconds for three minutes. Record your results in the table.

time / s	0	30	60	90	120	150	180
temperature of solution / °C	24.5°	23.5°	23.0°	22.5°	22.5°	22.5°	22.5°

[2]

(b) *Experiment 2*

Empty the polystyrene cup and rinse it with water.

Use a measuring cylinder to pour 25 cm^3 of distilled water into the polystyrene cup. Measure the temperature of the water and record it in the table below.

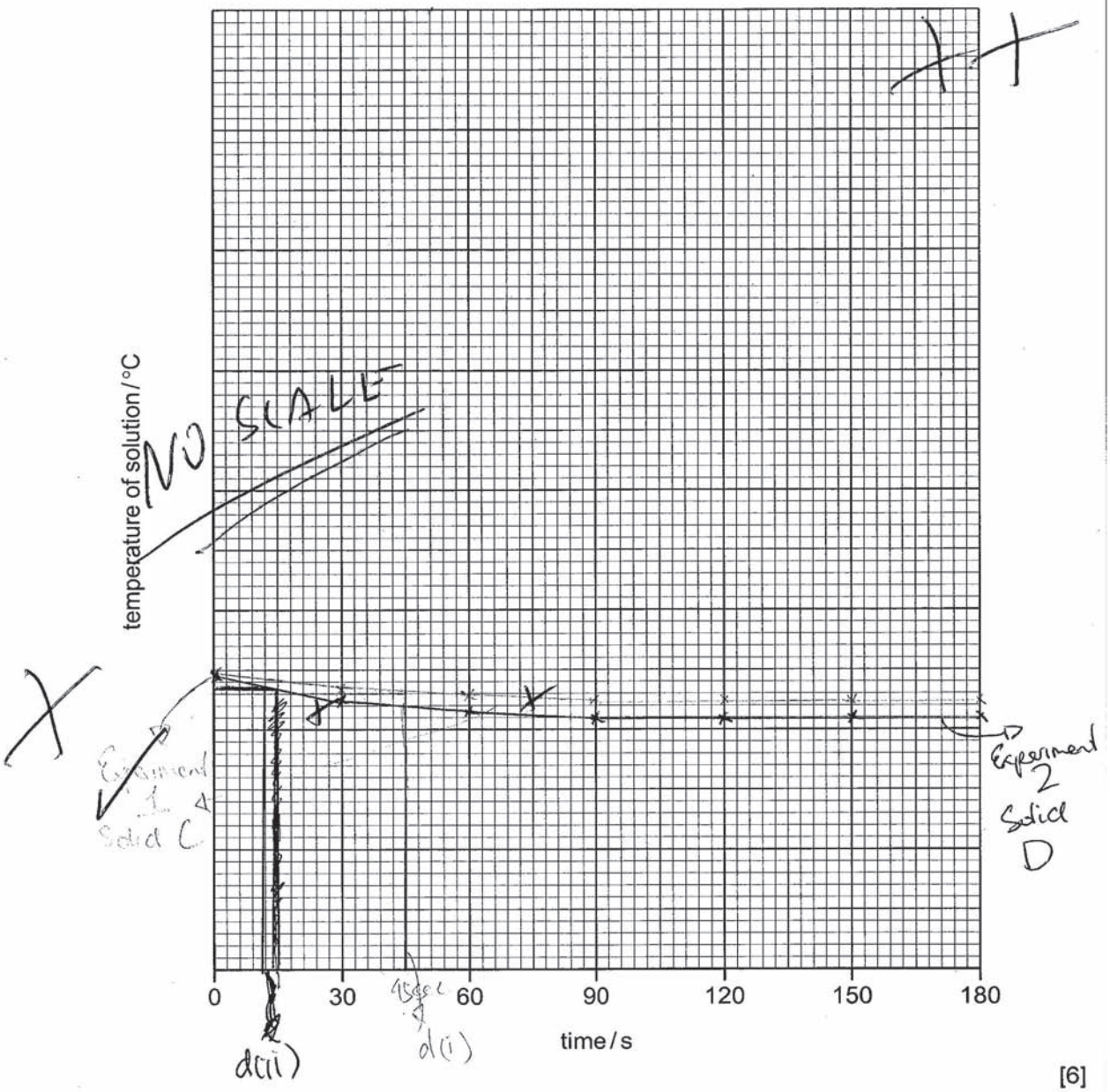
Add all of solid **D** to the water, start the timer and stir the mixture with the thermometer.

Measure the temperature of the solution every 30 seconds for three minutes. Record your results in the table.

time / s	0	30	60	90	120	150	180
temperature of solution / °C	~~25.0°~~ 24.5°	22.5°	21.5°	21.0°	21.0°	21.0°	21.0°

[2]

(c) Plot the results for Experiments 1 and 2 on the grid and draw two smooth line graphs. Clearly label your graphs.



[6]

(d) (i) **From your graph**, deduce the temperature of the solution in Experiment 1 after 45 seconds.
Show clearly **on the graph** how you worked out your answer.

23.2° ..... °C

[2]

(ii) **From your graph**, deduce how long it takes for the **initial** temperature of the solution in Experiment 2 to change by 1 °C.
Show clearly **on the graph** how you worked out your answer.

12 ..... s

[2]

(e) What type of change occurs when substance D dissolves in water?

Endothermic reaction. ✓ [1]

(f) Suggest and explain the effect on the results if Experiment 1 was repeated using 50 cm^3 of distilled water.

It would take more time and is harder for the solution to reduce in temperature. ✗ [2]

(g) Predict the temperature of the solution in Experiment 2 after 1 hour. Explain your answer.

Still around 21.0°, ✓ it is the maximum amount of temperature of cooled down with that amount. ✓ [2]

(h) When carrying out the experiments, what would be the advantage of taking the temperature readings every 15 seconds?

for more accurate result ✓ giving more details. [2]

[Total: 21]

Examiner comment – grade E

The candidate's answer in **(f)** showed a lack of understanding. Reference to 'taking more time' ignored the effect of using more water on the results. The temperature of the solution in experiment 1 was read every 30 seconds and the candidate missed the point that lower temperature changes would occur because of a greater volume of water being used.

A vague answer in **(g)** indicated that the candidate failed to realise that the reaction would return to room temperature. The idea of obtaining more accurate results scored partial credit in **(h)**.

Question 2

Mark scheme

2 **(a)** green (1) **reject**: any other colours, **ignore**: dark/light [1]

(b) (turns) black (1) condensation/drops at top of tube/steam/water (1)
limewater (1) milky/cloudy/white ppt (1) max 3 [3]

(c) **(i)** fizz/bubbles etc. (1)
blue solution/liquid (1) [2]

(ii) blue (1) **ignore**: qualifiers such as dark/light precipitate (1)
blue precipitate (1) (ignore qualifiers such as dark/light) [2]

(iii) dark/royal/deep blue (1) must be some indication it is darker than the ppt
solution/soluble/dissolves (1) [3]

(d) appearance: colourless (1)
smell: vinegar/pungent/sharp/sour/strong (1) [2]

(e) pH2–6 (1) [1]

(f) green or blue-green solution/liquid (1)
fizz/bubbles (1) [2]

(g) copper (1) carbonate (1) [2]

(h) acid/organic/ethanoic/acetic/vinegar [1]

[Total: 19]

Example candidate response – grade A

2 You are provided with solid **E** and liquid **F**.
Carry out the following tests on **E** and **F**, recording all of your observations in the table.
Conclusions must **not** be written in the table.

tests	observations
tests on solid **E** **(a)** Describe the appearance of solid **E**.	blue-green powder [1]
(b) Place half of solid **E** in a test-tube. Heat the test-tube gently. Test any gas given off.	The solid turns black. The gas turns limewater chalky. [3] carbon dioxide is present
(c) **(i)** Add half of the remaining solid **E** to about 5 cm^3 of dilute sulfuric acid in a test-tube. Allow the mixture to settle. Decant off the liquid into a test-tube. Divide the solution into two equal portions in test-tubes. Add 1 cm depth of distilled water to each test-tube and shake. Carry out the following tests. **(ii)** Add several drops of aqueous sodium hydroxide to the first portion of the solution and shake the test-tube. Now add excess sodium hydroxide to the test-tube. **(iii)** Add several drops of aqueous ammonia to the second portion of the solution and shake the test-tube. Now add excess aqueous ammonia to the test-tube.	There is effervescence Green solid at the bottom of test-tube [2] Blue precipitate is formed. The precipitate is insoluble [2] Blue precipitate is formed. Excess turns the solution to dark blue [3]

tests	observations
tests on liquid **F** **(d)** Describe the appearance and smell of liquid **F**.	appearance colorless ✓ [1] smell pungent ✓ [1]
(e) Use pH indicator paper to measure the pH of liquid **F**.	pH 3 ✓ [1]
(f) Add about 3 cm^3 of liquid **F** to the rest of solid **E** in a test-tube. Leave to stand for five minutes.	There is effervescence ✓ Green solid at the bottom of test-tube [2]

Examiner comment – grade A

Tests on solid **E**

The description of the solid was incorrect because any reference to colours other than green was penalised. The results to the tests on solid **E** in **(b)** were correct. The description of the colour change and the test for carbon dioxide were both well described.

The tests in part **(c)** were successfully performed and the results clearly recorded. The only point not credited was due to failing to note the formation of a blue solution in **(d)(i)**. However, descriptions of the formation of blue precipitates in parts **(iii)** and **(iv)** and the solubility of the precipitate in excess ammonia were accurately described.

Example candidate response – grade A

2 You are provided with solid **E** and liquid **F**.
Carry out the following tests on **E** and **F**, recording all of your observations in the table.
Conclusions must **not** be written in the table.

tests	observations
tests on solid **E** **(a)** Describe the appearance of solid **E**.	A fine dark green powder [1]
(b) Place half of solid **E** in a test-tube. Heat the test-tube gently. Test any gas given off.	The gas given off turns limewater milky and the solid darkens to a black powder. Carbon dioxide is produced. [3]
(c) **(i)** Add half of the remaining solid **E** to about 5 cm^3 of dilute sulfuric acid in a test-tube. Allow the mixture to settle. Decant off the liquid into a test-tube. Divide the solution into two equal portions in test-tubes. Add 1 cm depth of distilled water to each test-tube and shake. Carry out the following tests.	There is fizzing and a clear blue solution forms with a heavy green precipitate at the bottom. Carbon dioxide is produced from the fizzing. [2]
(ii) Add several drops of aqueous sodium hydroxide to the first portion of the solution and shake the test-tube. Now add excess sodium hydroxide to the test-tube.	A light blue precipitate forms and is insoluble in excess. [2]
(iii) Add several drops of aqueous ammonia to the second portion of the solution and shake the test-tube. Now add excess aqueous ammonia to the test-tube.	A light blue precipitate forms but dissolves in excess to give a dark blue solution [3]

tests	observations
tests on liquid **F**	
(d) Describe the appearance and smell of liquid **F**.	appearance it is a transparent ~~solution~~ [1] smell a sour smell [1]
(e) Use pH indicator paper to measure the pH of liquid **F**.	pH 2 [1]
(f) Add about 3 cm^3 of liquid **F** to the rest of solid **E** in a test-tube. Leave to stand for five minutes.	~~The two~~ There is a clear liquid and a green powder at ~~the~~ bottom. The two substances do not mix. [2]

(g) Identify solid **E**.

it is it contains Cu^{2+} and CO_3^{2-} ions; copper carbonate ~~word~~ ($CuCO_3$) [2]

(h) Draw **one** conclusion about liquid **F**.

it is a weak acid. [1]

[Total: 19]

Examiner comment – grade A

Tests on liquid **F**

In **(d)**, the appearance of liquid **F** was described as transparent instead of colourless, but the smell was correctly described. In **(e)**, the pH of the liquid was successfully measured and recorded. Correct conclusions as to the identity of solid **E** and liquid **F** were made in parts **(g)** and **(h)**.

This candidate is clearly able to follow instructions and successfully draw correct conclusions from the observations obtained.

Example candidate response – grade C

2 You are provided with solid **E** and liquid **F**.
Carry out the following tests on **E** and **F**, recording all of your observations in the table.
Conclusions must **not** be written in the table.

tests	observations
tests on solid **E** **(a)** Describe the appearance of solid **E**.	Green powder [1]
(b) Place half of solid **E** in a test-tube. Heat the test-tube gently. Test any gas given off.	Carbon dioxide produced pH value is 5 [3]
(c) **(i)** Add half of the remaining solid **E** to about 5 cm^3 of dilute sulfuric acid in a test-tube. H_2SO_4 Allow the mixture to settle. Decant off the liquid into a test-tube. Divide the solution into two equal portions in test-tubes. Add 1 cm depth of distilled water to each test-tube and shake. Carry out the following tests. **(ii)** Add several drops of aqueous sodium hydroxide to the first portion of the solution and shake the test-tube. Now add excess sodium hydroxide to the test-tube. **(iii)** Add several drops of aqueous ammonia to the second portion of the solution and shake the test-tube. Now add excess aqueous ammonia to the test-tube.	light blue ppt, soluble in excess, bubbles produced [2] Light blue ppt, insoluble in excess [2] ~~Purple solution~~ Light blue ppt, soluble in excess, a dark blue solution [3]

tests	observations
tests on liquid **F** **(d)** Describe the appearance and smell of liquid **F**.	appearance colourless [1] smell sour [1]
(e) Use pH indicator paper to measure the pH of liquid **F**.	pH 3 [1]
(f) Add about 3 cm^3 of liquid **F** to the rest of solid **E** in a test-tube. Leave to stand for five minutes.	Bubbles produced, light blue ppt insoluble in excess [2]

(g) Identify solid **E**.

copper [2]

(h) Draw **one** conclusion about liquid **F**.

carbonate solution [1]

[Total: 19]

Examiner comment – grade C

Tests on solid **E**

Question 2 was successfully attempted. The appearance of the solid was correctly described in **(a)**. The candidate did not follow the instructions in **(b)** and no observations were recorded. The test and result for the gas given off were not described.

The tests and observations were correctly performed and described in part **(c)(i)**. The formation of bubbles when dilute sulfuric acid was added to the solid gained a mark. However, the description of the formation of a blue precipitate instead of a blue solution was penalised.

Tests on liquid **F**

The appearance, smell and pH of the liquid were correctly described in **(d)** and **(e)**. A limited ability to draw conclusions was evident in **(g)** and **(h)**. The presence of copper was recognised but the idea that solid **E** was a compound of copper, ie copper carbonate, was not realised. This candidate was unable to draw a correct conclusion about liquid **F** from the tests carried out.

Example candidate response – grade E

2 You are provided with solid **E** and liquid **F**.
Carry out the following tests on **E** and **F**, recording all of your observations in the table.
Conclusions must **not** be written in the table.

tests	observations
tests on solid **E** **(a)** Describe the appearance of solid **E**.	Green ~~powdery~~ solid [1]
(b) Place half of solid **E** in a test-tube. Heat the test-tube gently. Test any gas given off.	Turns into a black ~~liquid~~ liquid Hydrogen gas given off. [3]
(c) **(i)** Add half of the remaining solid **E** to about 5 cm^3 of dilute sulfuric acid in a test-tube. Allow the mixture to settle. Decant off the liquid into a test-tube. Divide the solution into two equal portions in test-tubes. Add 1 cm depth of distilled water to each test-tube and shake. Carry out the following tests. **(ii)** Add several drops of aqueous sodium hydroxide to the first portion of the solution and shake the test-tube. Now add excess sodium hydroxide to the test-tube. **(iii)** Add several drops of aqueous ammonia to the second portion of the solution and shake the test-tube. Now add excess aqueous ammonia to the test-tube.	Becomes cloudy when sulphuric acid is added. ~~Becomes a liquid~~ [2] Bubbles ~~Becomes cloudy~~ solution Turns Blue [2] Solution Turns milky and cloudy before becoming colourless. Light Blue ~~precipitate~~ solution ~~remains at the top of the test tube tube whilst the solution at the bottom is colourless~~ [3]

tests	observations
tests on liquid **F** **(d)** Describe the appearance and smell of liquid **F**.	appearance ..... colourless liquid ..... [1] smell ..... vinegar, acidic ..... [1]
(e) Use pH indicator paper to measure the pH of liquid **F**.	pH ..... ~~2~~ 2 ..... [1]
(f) Add about 3 cm^3 of liquid **F** to the rest of solid **E** in a test-tube. Leave to stand for five minutes.	..... No change .... Bubbles ~~visibly~~ rising ..... [2]

(g) Identify solid **E**.

..... Copper ..... [2]

(h) Draw **one** conclusion about liquid **F**.

..... Liquid F does not react with solid E because ~~liquid~~ copper F ~~is unreactive~~. is a less reactive metal. ..... [1]

[Total: 19]

Examiner comment – grade E

Tests on solid **E**

Question 2 was carried out as instructed. The ability to describe the solid correctly was evident in **(a)**. The action of heat on the solid in **(b)** was carried out. The candidate did not test the gas given off and wrongly guessed the presence of chlorine. The incorrect use of the term precipitate was also apparent.

Compared to a grade C candidate, the tests in **(c)** showed less accurate answers. In **(c)(i)**, no reference was made to the formation of bubbles and the solution was incorrectly referred to as turquoise. The unreacted solid was wrongly described as a 'green precipitate' which showed a lack of understanding. Some credit was scored in **(c)(ii)** and **(iii)**. However, part **(iii)** revealed confusion stating 'the solution became colourless', instead of realising that the precipitate had in fact dissolved.

Example candidate response – grade E

2 You are provided with solid **E** and liquid **F**.
Carry out the following tests on **E** and **F**, recording all of your observations in the table.
Conclusions must **not** be written in the table.

tests	observations
tests on solid **E** **(a)** Describe the appearance of solid **E**.	green powder (solid) [1]
(b) Place half of solid **E** in a test-tube. Heat the test-tube gently. Test any gas given off.	no gas/use present. [3]
(c) (i) Add half of the remaining solid **E** to about 5 cm^3 of dilute sulfuric acid in a test-tube. Allow the mixture to settle. Decant off the liquid into a test-tube. Divide the solution into two equal portions in test-tubes. Add 1 cm depth of distilled water to each test-tube and shake. Carry out the following tests. **(ii)** Add several drops of aqueous sodium hydroxide to the first portion of the solution and shake the test-tube. Now add excess sodium hydroxide to the test-tube. **(iii)** Add several drops of aqueous ammonia to the second portion of the solution and shake the test-tube. Now add excess aqueous ammonia to the test-tube.	effervescence, turn light blue [2] light blue ppt, insoluble in excess [2] light blue ppt, soluble in excess, and give dark blue solutions [3]

tests	observations
tests on liquid **F** **(d)** Describe the appearance and smell of liquid **F**.	appearance transparent. [1] smell acidic, sour [1]
(e) Use pH indicator paper to measure the pH of liquid **F**.	pH 3 [1]
(f) Add about 3 cm^3 of liquid **F** to the rest of solid **E** in a test-tube. Leave to stand for five minutes.	insoluble in excess giving residue in bottom [2]

(g) Identify solid **E**.

copper (Cu^{2+}) [2]

(h) Draw **one** conclusion about liquid **F**.

It is an acidic solution. [1]

[Total: 19]

Examiner comment – grade E

Tests on liquid **F**

The appearance of the liquid scored no credit for 'transparent' instead of colourless but the smell was correctly described. Part **(f)** showed no evidence of the expected observations and indicated that the instructions given had not been followed.

There was some attempt at drawing conclusions in **(g)** and **(h)**.

Paper 6 – Alternative to practical

Paper 6 is a written paper designed to test candidates' familiarity with laboratory based procedures. The purpose of this component is to test appropriate skills in assessment objective C (Experimental skills and investigations). Candidates are not required to use knowledge outside the Core curriculum.

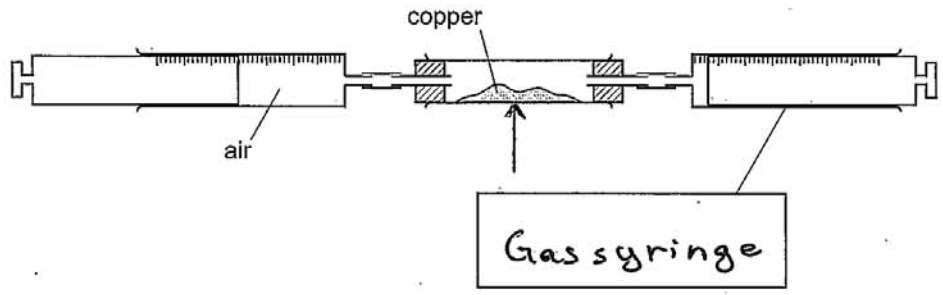
Question 1

Mark scheme

1	(a)	(i)	(gas) syringe (1)	[1]
		(ii)	arrow indication under copper (1)	[1]
	(b)		spatula (1)	[1]
	(c)		black (1)	[1]
	(d)		to return to room/initial temperature (1) correct volume of gas (1)	[2]

Example candidate response – grade A

1 A student investigated the reaction of air with copper. 100 cm^3 of air was passed continuously over heated copper using the apparatus below. When the volume remained constant, the apparatus was left to cool and the volume of gas was measured.



(a) **(i)** Complete the box to show the apparatus labelled. [1]

(ii) Indicate on the diagram, with an arrow, where heat is applied. [1]

(b) What should be used to transfer the copper from a bottle to the apparatus?

a spatula [1]

(c) The copper changed colour from brown to black [1]

(d) Why was the apparatus left to cool before measuring the final volume of gas?

so it could get to the original temperature (room), otherwise the volume would be bigger and the result would be unprecise [2]

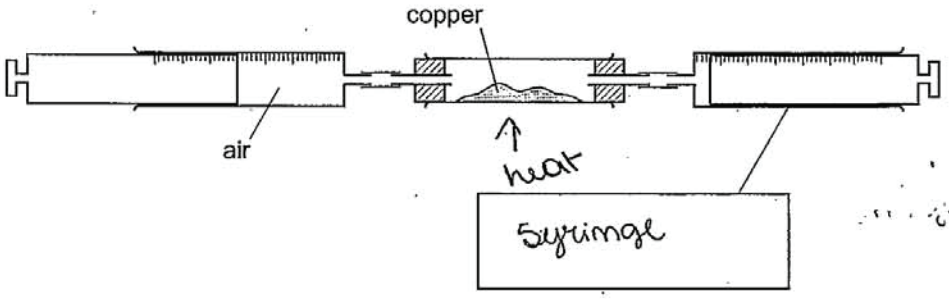
[Total: 6]

Examiner comment – grade A

The answer to **1(a)** shows a familiarity with apparatus. The candidate successfully identified the gas syringe and inserted the heat arrow in the correct location. The candidate clearly understood in **(d)** that the gas needs to return to room temperature in order to obtain an accurate volume measurement.

Example candidate response – grade C

1 A student investigated the reaction of air with copper. 100 cm^3 of air was passed continuously over heated copper using the apparatus below. When the volume remained constant, the apparatus was left to cool and the volume of gas was measured.



(a) (i) Complete the box to show the apparatus labelled. [1]

(ii) Indicate on the diagram, with an arrow, where heat is applied. [1]

(b) What should be used to transfer the copper from a bottle to the apparatus?

Measuring cylinder ..... [1]

(c) The copper changed colour from brown to pink ..... [1]

(d) Why was the apparatus left to cool before measuring the final volume of gas?

So the pressure of the gases should be smaller and it will not burn the hand of the student. [2]

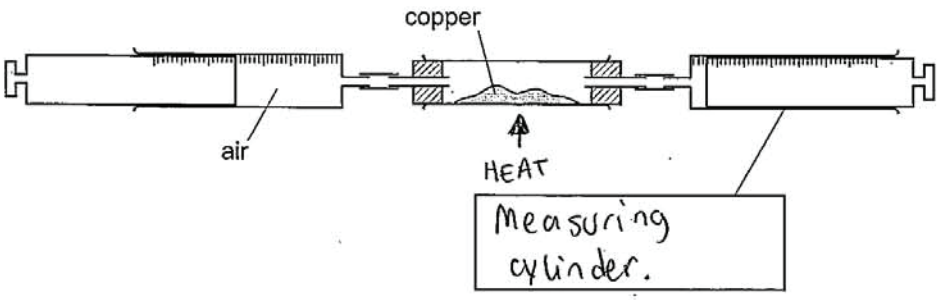
[Total: 6]

Examiner comment – grade C

In Question 1 the candidate correctly identified the apparatus and identified where heat was applied. The answer to **(b)** showed a lack of understanding. Instead of specifying a spatula the candidate indicated that a measuring cylinder should be used to transfer a solid. In **(d)**, the idea of letting the gas cool to room temperature to obtain an accurate volume measurement was not realised.

Example candidate response – grade E

1 A student investigated the reaction of air with copper. 100 cm^3 of air was passed continuously over heated copper using the apparatus below. When the volume remained constant, the apparatus was left to cool and the volume of gas was measured.



(a) (i) Complete the box to show the apparatus labelled. [1]

(ii) Indicate on the diagram, with an arrow, where heat is applied. [1]

(b) What should be used to transfer the copper from a bottle to the apparatus?

~~A spatula~~ A syringe. A Syringe. [1]

(c) The copper changed colour from brown to colourless. [1]

(d) Why was the apparatus left to cool before measuring the final volume of gas?

Because the volume of gas can be less when the temperature is decreased. [2]

[Total: 6]

Examiner comment – grade E

In **(a)(i)**, the apparatus was incorrectly identified as a measuring cylinder instead of a gas syringe. Confusion was evident in **(b)** where a syringe was used by the candidate to transfer the copper. A spatula was the expected correct response. The candidate mistakenly stated that the copper changes from brown to colourless in **(c)** which showed a lack of knowledge of transition metal chemistry. In **(d)**, some understanding is shown that gases change volume when the temperature varies.

Question 2

Mark scheme

2 **(a)** points plotted correctly (2)
smooth line graph missing anomalous point (1) [3]

(b) point at 15 cm^3/pH 2.6/third point (1) [1]

(c) **(i)** 12.6 (1) [1]

(ii) pH 1 (1) extrapolation shown (1) [2]

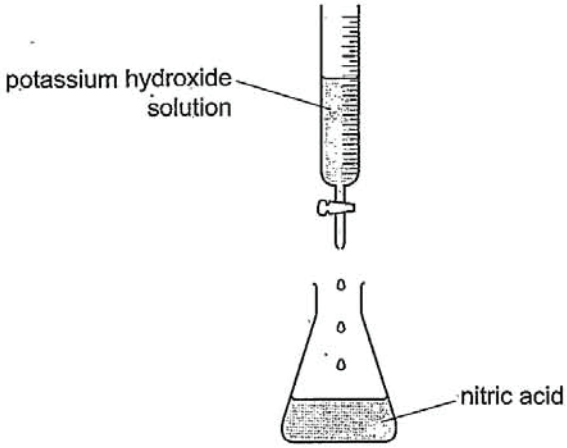
(d) **(i)** 7 (1) [1]

(ii) 25 (1) [1]

(e) repeat experiment (1) stop when 25 cm^3 added/when pH7 (1)
evaporate/heat (1) use same volumes (1)
to crystallising point/until saturated (1) max [3]

Example candidate response – grade A

2 A student prepared a sample of potassium nitrate by neutralising nitric acid using potassium hydroxide solution.
25.0 cm^3 of nitric acid was poured into a conical flask. Potassium hydroxide was added a little at a time from a burette as shown below.



After each addition of potassium hydroxide solution the pH was measured with a pH meter and the values recorded in the table of results.

volume of potassium hydroxide solution added / cm^3	pH value
5.0	1.2
10.0	1.4
15.0	2.6
20.0	2.0
24.0	2.7
24.5	3.0
25.5	11.0
26.0	11.3
30.0	12.0
40.0	13.2

You are going to draw a graph to find the volume of potassium hydroxide solution required to neutralise the 25.0 cm^3 of nitric acid.

(d) **(i)** What is the pH of the solution when all of the nitric acid has just been neutralised?

pH 7. [1]

(ii) What volume of potassium hydroxide was required to neutralise 25.0 cm^3 of nitric acid?

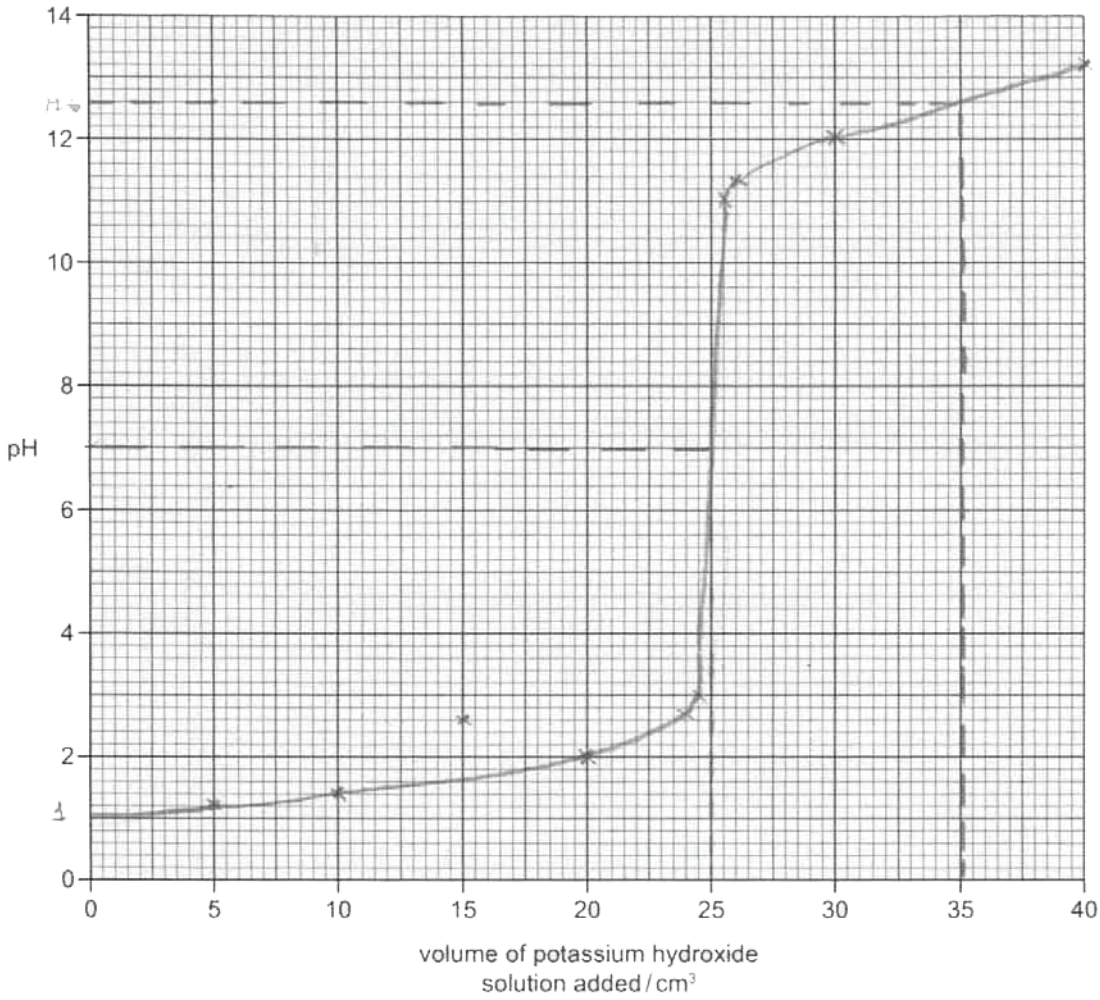
25cm^3 [1]

(e) Describe how the student should modify the experiment to obtain pure crystals of potassium nitrate.

Heat the solution until crystallisation point. Let the crystals cool. Filter the crystals. Dry the crystals carefully with the filter paper. [3]

[Total: 12]

(a) Plot the results on the grid below and draw a smooth line graph.



[3]

(b) Which point appears to be inaccurate?

At 15cm³ of potassium hydroxide [1]

(c) **(i)** **Use your graph** to find the pH of the solution when 35.0 cm³ of potassium hydroxide was added.

pH 12.6 [1]

(ii) **Use your graph** to find the pH of 25.0 cm³ of nitric acid.

Show clearly **on the grid** how you obtained your answer.

pH 1 [2]

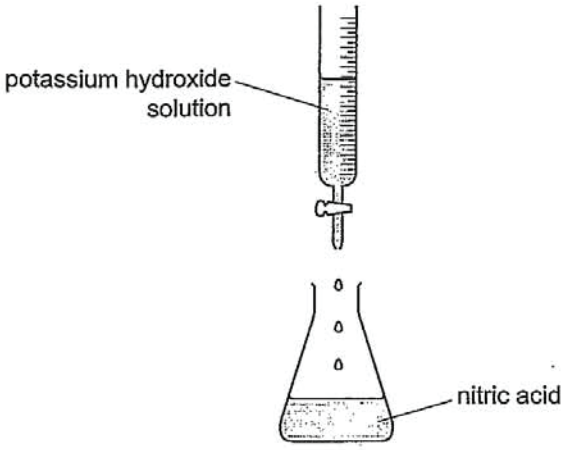
Examiner comment – grade A

In **2(a)** and **(b)**, the candidate is able to present the information as correctly plotted points and a smooth line graph, omitting the inaccurate point, on the grid provided. In **(c)(i)**, the candidate is able to use the graph, and in **(c)(ii)**, extrapolate the graph to find the pH of the nitric acid. In **2(d)**, the candidate has a clear understanding and knowledge of the neutralisation process.

In **2(e)**, the candidate scored partial credit for heating the solution to crystallising point. The answer lacks detail as to the solution which should be used.

Example candidate response – grade C

2 A student prepared a sample of potassium nitrate by neutralising nitric acid using potassium hydroxide solution.
25.0 cm^3 of nitric acid was poured into a conical flask. Potassium hydroxide was added a little at a time from a burette as shown below.

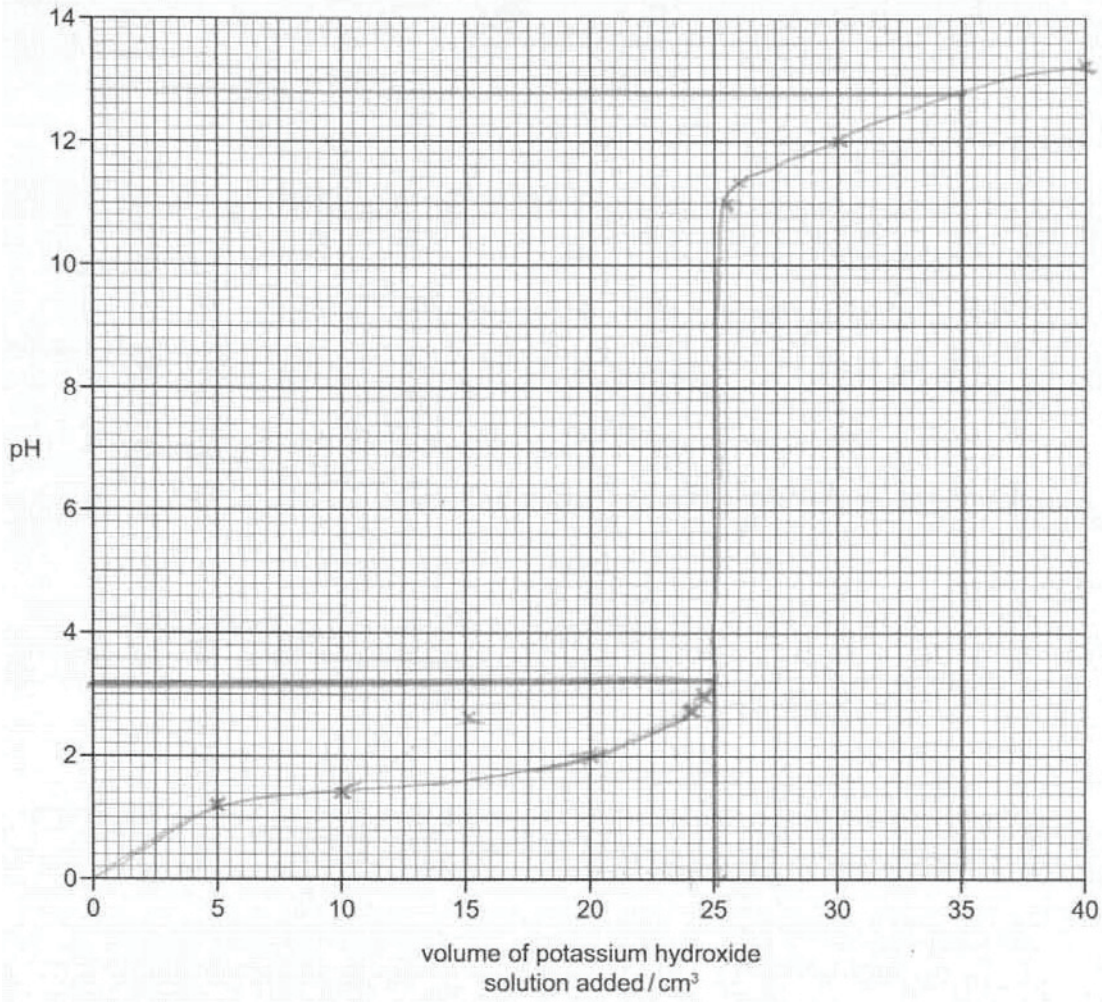


After each addition of potassium hydroxide solution the pH was measured with a pH meter and the values recorded in the table of results.

volume of potassium hydroxide solution added / cm^3	pH value
5.0	1.2
10.0	1.4
15.0	2.6
20.0	2.0
24.0	2.7
24.5	3.0
25.5	11.0
26.0	11.3
30.0	12.0
40.0	13.2

You are going to draw a graph to find the volume of potassium hydroxide solution required to neutralise the 25.0 cm^3 of nitric acid.

(a) Plot the results on the grid below and draw a smooth line graph.



[3]

(b) Which point appears to be inaccurate?

The third point (vol of potassium is, ph 2.6) [1]

(c) **(i)** **Use your graph** to find the pH of the solution when 35.0 cm³ of potassium hydroxide was added.

12.8 cm³ [1]

(ii) **Use your graph** to find the pH of 25.0 cm³ of nitric acid.

Show clearly **on the grid** how you obtained your answer.

3.2 cm³ [2]

(d) (i) What is the pH of the solution when all of the nitric acid has just been neutralised?

7 ..... [1]

(ii) What volume of potassium hydroxide was required to neutralise 25.0 cm^3 of nitric acid?

25 cm3 ..... [1]

(e) Describe how the student should modify the experiment to obtain pure crystals of potassium nitrate.

~~(The student should heat it, wait until~~ heat it

The student should filter the solution, then heat

~~the salt~~ filter it and they will have the

crystals

..... [3]

[Total: 12]

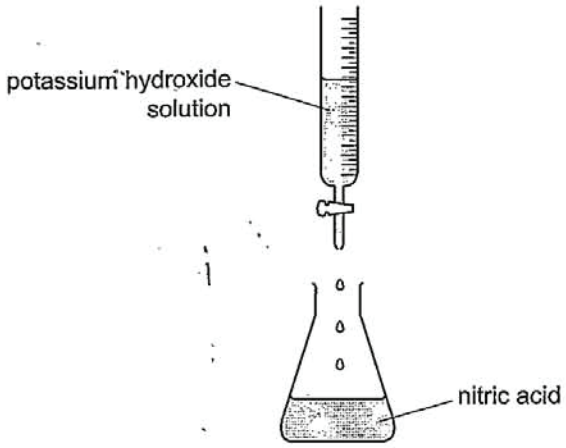
Examiner comment – grade C

The graph in **2(a)** was correctly plotted and a smooth curve drawn as appropriate. The candidate was able to handle the information required for **(b)** and **(c)(i)**. However, compared to an grade A candidate, there was evidence in **(c)(ii)** of a lack of understanding. The answer shows that the candidate did not realise that the pH of the nitric acid could be obtained by extrapolation and reading when 0 cm^3 of potassium hydroxide had been added.

Part **(e)** showed a lack of knowledge and understanding of obtaining crystals by evaporating a solution to crystallising point.

Example candidate response – grade E

2 A student prepared a sample of potassium nitrate by neutralising nitric acid using potassium hydroxide solution.
25.0 cm^3 of nitric acid was poured into a conical flask. Potassium hydroxide was added a little at a time from a burette as shown below.

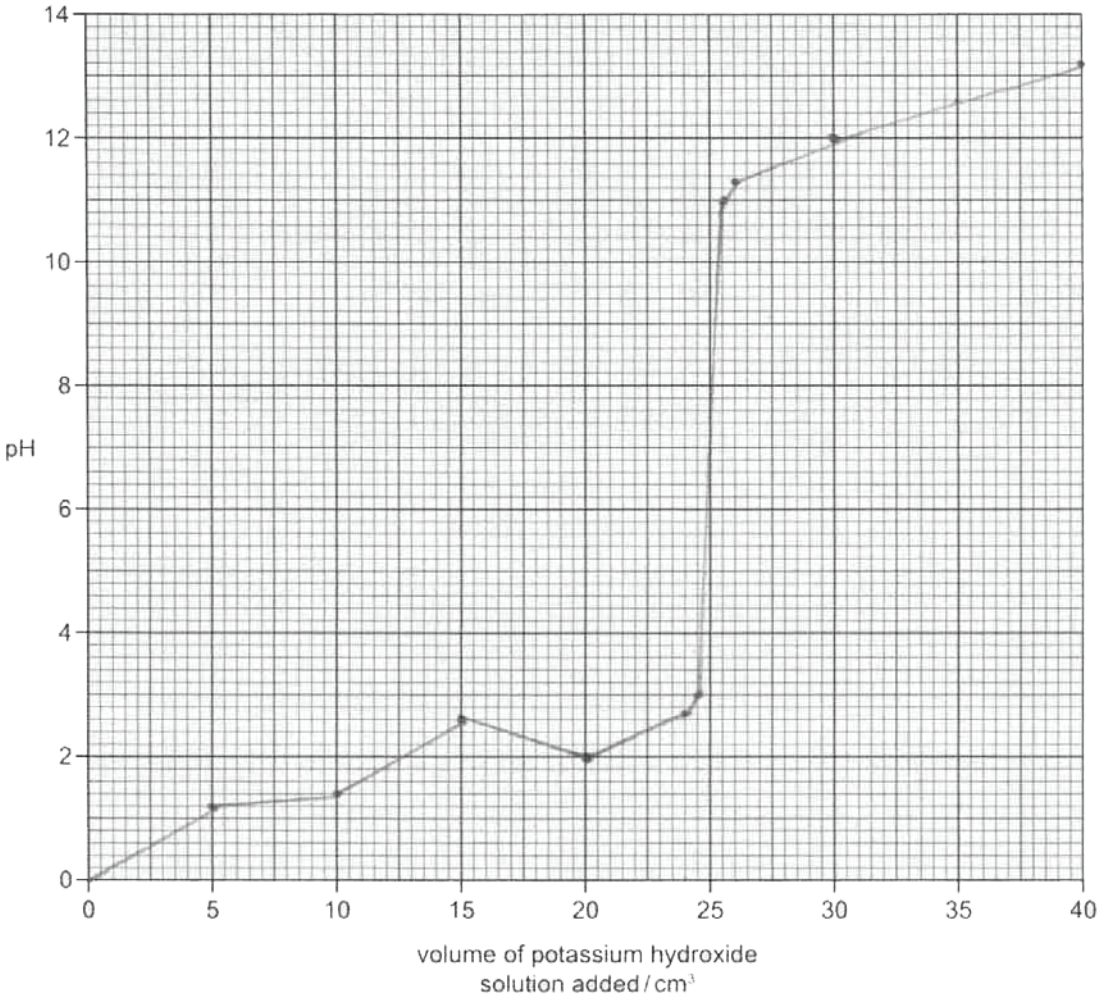


After each addition of potassium hydroxide solution the pH was measured with a pH meter and the values recorded in the table of results.

volume of potassium hydroxide solution added / cm^3	pH value
5.0	1.2
10.0	1.4
15.0	2.6
20.0	2.0
24.0	2.7
24.5	3.0
25.5	11.0
26.0	11.3
30.0	12.0
40.0	13.2

You are going to draw a graph to find the volume of potassium hydroxide solution required to neutralise the 25.0 cm^3 of nitric acid.

(a) Plot the results on the grid below and draw a smooth line graph.



[3]

(b) Which point appears to be inaccurate?

20 cm³ OF POTASSIUM HYDROXIDE / 2 PH ..... [1]

(c) **(i)** **Use your graph** to find the pH of the solution when 35.0 cm³ of potassium hydroxide was added.

12.6 ..... [1]

(ii) **Use your graph** to find the pH of 25.0 cm³ of nitric acid.

Show clearly **on the grid** how you obtained your answer.

7 ..... [2]

(d) (i) What is the pH of the solution when all of the nitric acid has just been neutralised?

THE CONCENTRATION GRADIENT ..... [1]

(ii) What volume of potassium hydroxide was required to neutralise 25.0 cm^3 of nitric acid?

50.0 cm^3 OF AN POTASSIUM HYDROXIDE [1]

(e) Describe how the student should modify the experiment to obtain pure crystals of potassium nitrate.

THE OBTAIN PURE CRYSTALS OF POTA-
SSIUM NITRATE THE STUDENT HAD
TO SEPARATE THE CRYSTALS BY USING
THE SEPARATION METHOD CRYSTALLISATION.

..... [3]

[Total: 12]

Examiner comment – grade E

In **2(a)**, the points are plotted correctly but the graph is drawn through the anomalous point and is not a smooth line. In **(b),** the candidate is unable to identify the inaccurate point. The candidate is unable to use the graph to answer **2(c)(ii)** and **2(d)** and shows a lack of understanding of neutralisation.

Question 3

Mark scheme

3 **(a)** chromatography (1) [1]

(b) line drawn on diagram below origin (1) [1]

(c) does not interfere with results/owtte (1) [1]

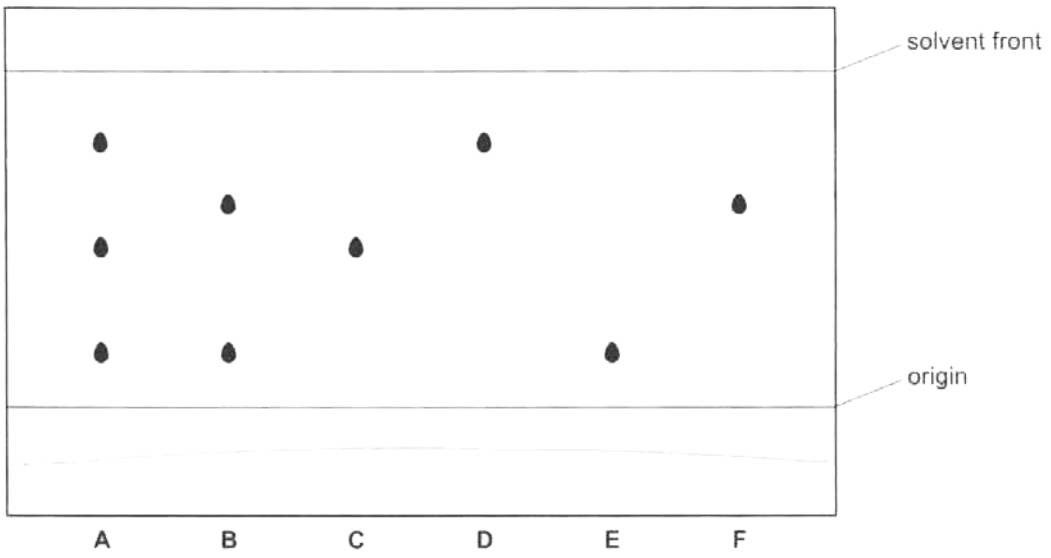
(d) difference
A has more/3 colours/**B** has less/2 colours/**B** contains **F** but **A** doesn't/**A** contains **C**/**D** but **B** does not (1)

similarity
both contain same colour/**E** (1) [2]

(e) **C**, **D** and **E** (1) [1]

Example candidate response – grade A

3 The diagram shows the results of an experiment to separate and identify the colours present in two coloured mixtures, **A** and **B**.
Substances **C**, **D**, **E** and **F** are single colours.



(a) Name this method of separation.

Chromatography. [1]

(b) Draw a line **on the diagram** to show the level of the solvent at the beginning of the experiment. [1]

(c) Why should a pencil be used instead of a pen to draw the origin line?

So that the ink from the pen doesn't obsure / alter the results [1]

(d) State **one** difference and **one** similarity between the coloured mixtures, **A** and **B**.

difference A contain substance C but B has F instead. A also has same of D.

similarity both contain substances E

[2]

(e) Which substances are present in mixture **A**?

E, C and D [1]

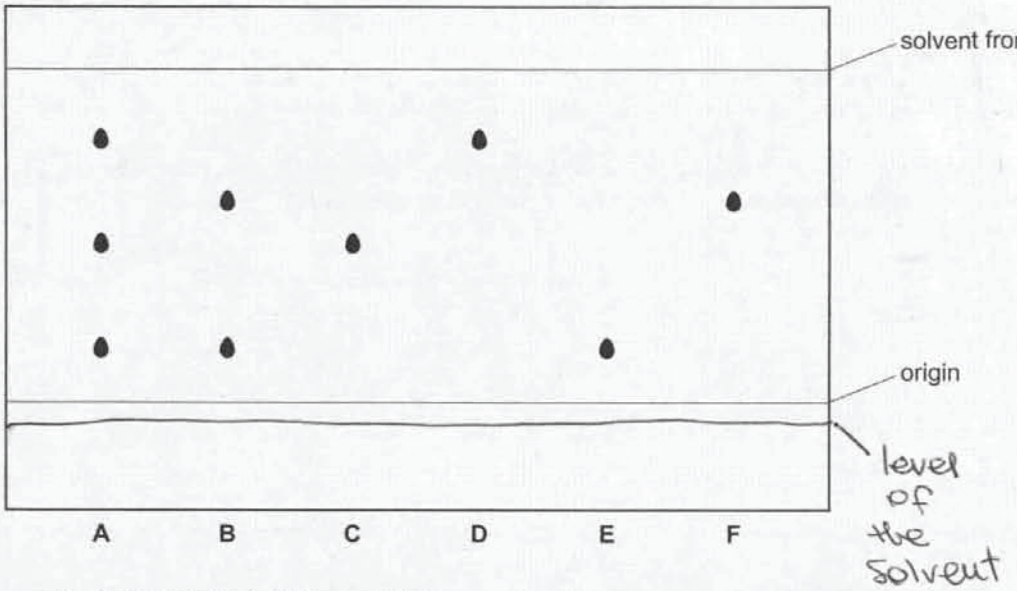
[Total: 6]

Examiner comment – grade A

Question 3 shows a good knowledge and understanding of chromatography. The answers to **(b)** and **(c)** show experience of carrying out this separation process. The interpretation of the chromatogram in **(d)** and **(e)** is fully and correctly detailed. The candidate is clearly able to identify the three substances present in mixture A.

Example candidate response – grade C

3 The diagram shows the results of an experiment to separate and identify the colours present in two coloured mixtures, **A** and **B**.
Substances **C**, **D**, **E** and **F** are single colours.



(a) Name this method of separation.

Chromatography ..... [1]

(b) Draw a line **on the diagram** to show the level of the solvent at the beginning of the experiment. [1]

(c) Why should a pencil be used instead of a pen to draw the origin line?

Because the pen contains different colours on its ink. ..... [1]

(d) State **one** difference and **one** similarity between the coloured mixtures, **A** and **B**.

difference mixture B ~~contains~~ is made of two colours and mixture A of 3. .....

similarity the first colour that appears in both mixtures is the same ..... [2]

(e) Which substances are present in mixture **A**?

D and E ..... [1]

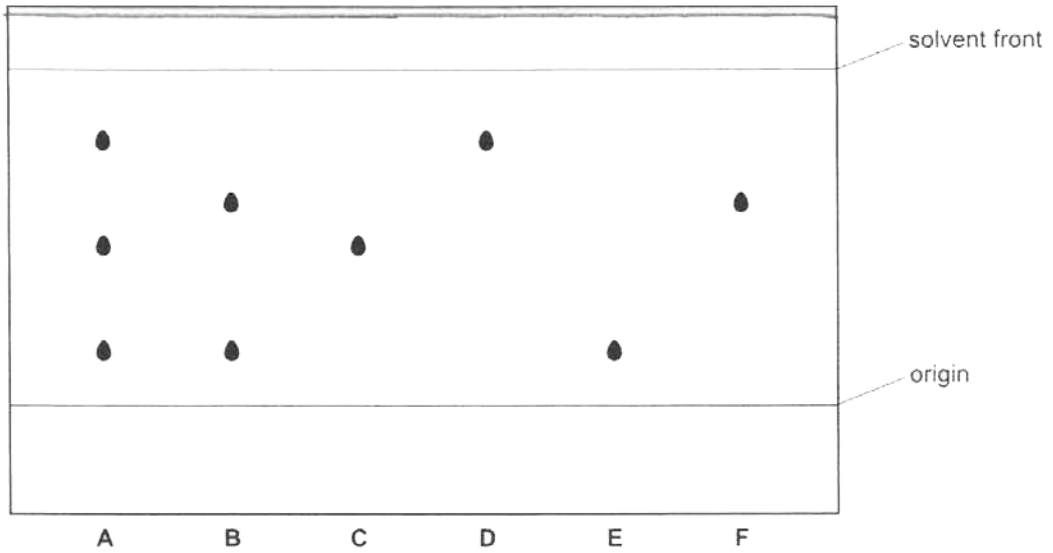
[Total: 6]

Examiner comment – grade C

Parts **(a)** and **(b)** showed that the candidate had practical experience of the chromatography process. Essential detail was missing in **(c)**. The candidate did clearly specify that the ink from a pen would interfere with the results. The interpretation of the chromatogram in **(d)** was correct, but all of the substances in mixture A were not identified in **(e)**.

Example candidate response – grade E

3 The diagram shows the results of an experiment to separate and identify the colours present in two coloured mixtures, **A** and **B**.
Substances **C**, **D**, **E** and **F** are single colours.



(a) Name this method of separation.

CHROMATOGRAPHY [1]

(b) Draw a line **on the diagram** to show the level of the solvent at the beginning of the experiment. [1]

(c) Why should a pencil be used instead of a pen to draw the origin line?

BECAUSE THE INK OF THE PEN CAN AFFECT THE RESULT [1]

(d) State **one** difference and **one** similarity between the coloured mixtures, **A** and **B**.

difference SUBSTANCE A IS NOT COMPOSE OF THREE MIXTURES AND B OF TWO

similarity THEY ARE BOTHS IMPURE SUBSTANCES

[2]

(e) Which substances are present in mixture **A**?

TH IMPURE SUBSTANCES [1]

[Total: 6]

Examiner comment – grade E

The candidate recognised the method of separation in **(a)**. Part **(b)** showed a lack of understanding of the term 'origin'. The interpretation of the chromatogram in **(d)** and **(e)** revealed very limited understanding.

Question 4

Mark scheme

4 **(a)** Table of results for Experiment 1
temperature boxes completed correctly (3)
20, 21, 21, 32, 39, 42, 44, 45, 45 [3]

(b) Table of results for Experiment 2
temperature boxes completed correctly (3)
20, 21, 21, 24, 32, 36, 37, 38, 38 [3]

(c) all points correctly plotted (3) -1 for each incorrect
best fit smooth line graphs (1)
labels (1) [5]

(d) value from graph ≈28°C ± half small square (1) unit (1) shown clearly (1) [3]

(e) exothermic/redox/displacement (1) [1]

(f) **(i)** temperature rises greater/faster in Experiment 1 (1) **allow** converse [1]

(ii) zinc is more reactive (1) [1]

(g) temperature changes would be same/faster/owtte (1) metal in excess (1)/
temperature changes would be greater (1) lower volume (1) [2]

(h) solid would react slower/temperature rises would be slower (1)
smaller surface area (1) [2]

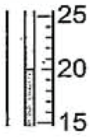
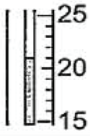
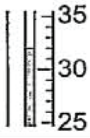
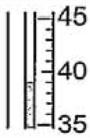
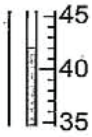
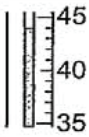
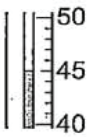
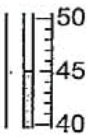
Example candidate response – grade A

4 A student investigated the reaction between aqueous copper(II) sulfate and two different metals, zinc and iron.
Two experiments were carried out.

Experiment 1
Using a measuring cylinder, 25 cm^3 of aqueous copper(II) sulfate was poured into a polystyrene cup. The temperature of the solution was measured. The timer was started and the temperature was measured every half a minute for one minute.

At 1 minute, 5 g of zinc powder was added to the cup and the mixture stirred with the thermometer. The temperature of the mixture was measured every half minute for an additional three minutes.

(a) Use the thermometer diagrams in the table to record the temperatures.

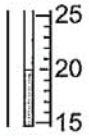
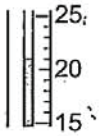
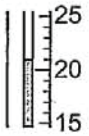
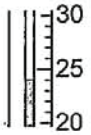
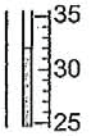
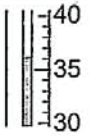
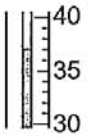
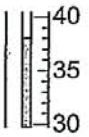
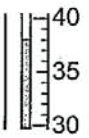
time / min	thermometer diagrams	temperature / °C
0.0		20
0.5		21
1.0		21
1.5		32
2.0		39
2.5		42
3.0		44
3.5		45
4.0		45

[3]

Experiment 2

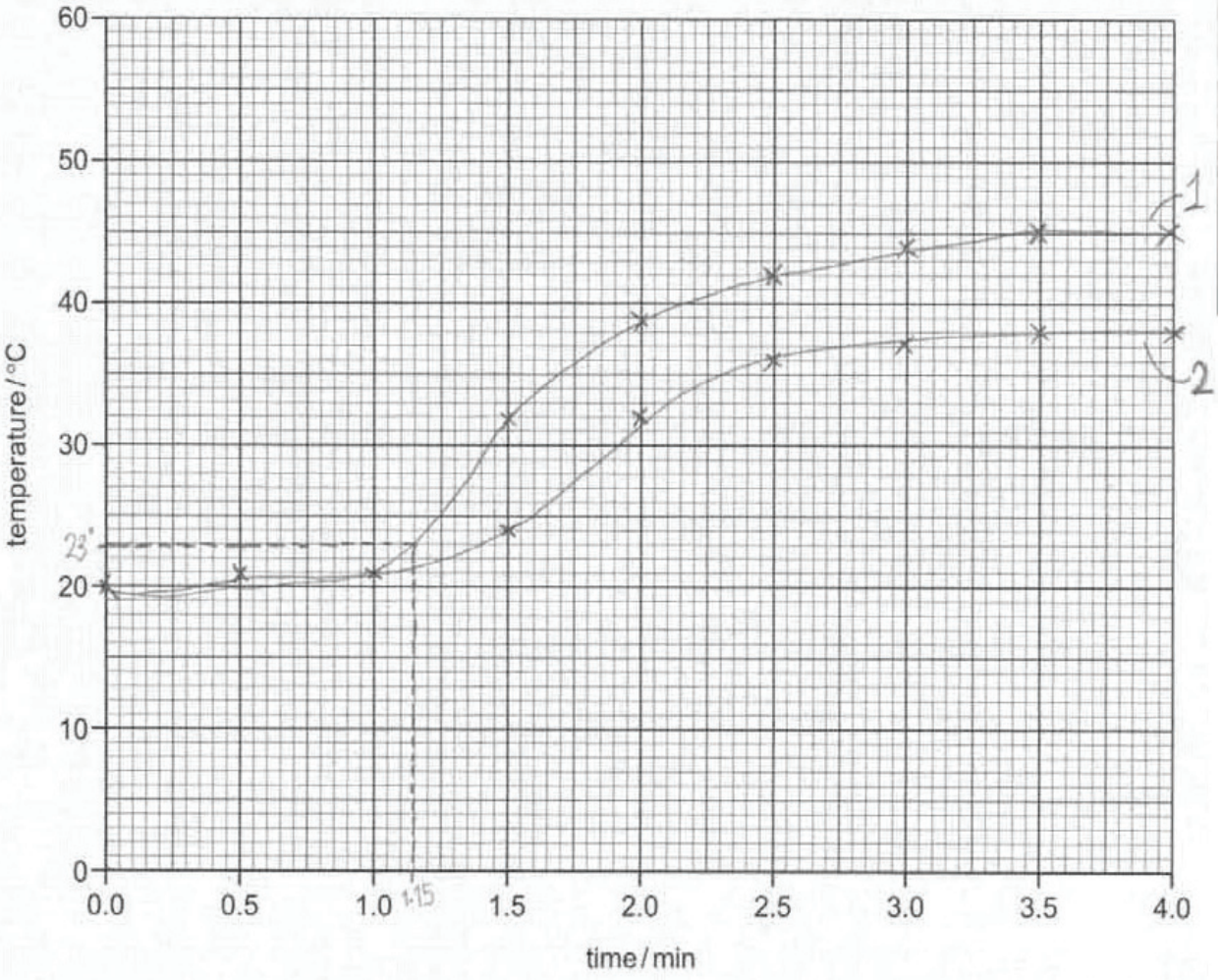
Experiment 1 was repeated using 5 g of iron powder instead of the zinc powder.

(b) Use the thermometer diagrams in the table to record the temperatures.

time / min	thermometer diagrams	temperature / °C
0.0		20
0.5		21
1.0		21
1.5		24
2.0		32
2.5		36
3.0		37
3.5		38
4.0		38

[3]

(c) Plot the results of both experiments on the grid below. Draw two smooth line graphs. Clearly label your graphs.



[5]

(d) **From your graph**, work out the temperature of the reaction mixture in Experiment 1 after 1 minute 15 seconds. Show clearly **on the graph** how you worked out your answer.

23°C ..... [3]

(e) What type of chemical process occurs when zinc and iron react with aqueous copper(II) sulfate?

exothermic reaction ..... [1]

(f) **(i)** Compare the temperature changes in Experiments 1 and 2.

Experiment 1 has a greater temperature change than Experiment 2. [1]

(ii) Suggest an explanation for the difference in temperature changes.

The zinc powder was more reactive than the iron powder [1]

(g) Explain how the temperature changes would differ in the experiments if 12.5 cm^3 of copper(II) sulfate solution were used.

The temperature changes would not be a big due to less copper(II) sulfate solution to react with. [2]

(h) Predict the effect of using lumps of zinc in Experiment 1. Explain your answer.

lumps would mean a smaller surface area which would mean slower less reaction. the temperature wouldn't rise as quickly, and maybe not as high. [2]

[Total: 21]

Examiner comment – grade A

The temperatures in the tables **(a)** and **(b)** are correctly completed. The candidate is able to present the information as correctly plotted points in **(c)** and drew two smooth line graphs, which are clearly labelled for maximum marks. In **(d)**, the candidate misread the scale on the x axis and worked out the temperature after 69 seconds instead of 75 seconds. In **4(f)**, the candidate is able to compare and explain the temperature changes in terms of the reactivity of the metals. In **(g)**, the candidate failed to appreciate that the temperature changes would be faster or greater if less copper sulfate solution were used. In **4(h)**, the understanding was demonstrated that a decrease in the rate of reaction would be due to a smaller surface area.

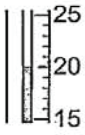
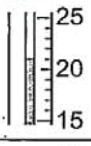
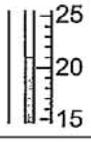
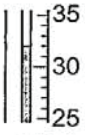
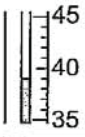
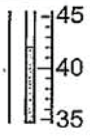
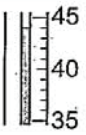
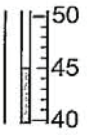
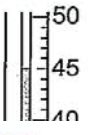
Example candidate response – grade C

4 A student investigated the reaction between aqueous copper(II) sulfate and two different metals, zinc and iron.
Two experiments were carried out.

Experiment 1
Using a measuring cylinder, 25 cm^3 of aqueous copper(II) sulfate was poured into a polystyrene cup. The temperature of the solution was measured. The timer was started and the temperature was measured every half a minute for one minute.

At 1 minute, 5 g of zinc powder was added to the cup and the mixture stirred with the thermometer. The temperature of the mixture was measured every half minute for an additional three minutes.

(a) Use the thermometer diagrams in the table to record the temperatures.

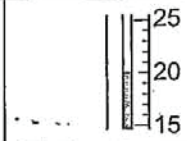
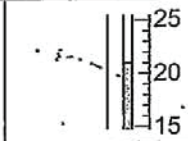
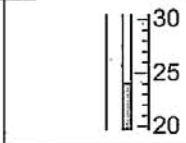
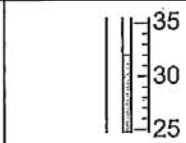
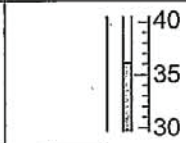
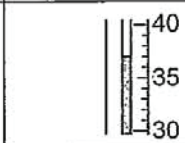
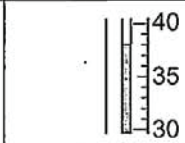
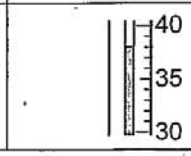
time / min	thermometer diagrams	temperature / °C
0.0		20°C
0.5		21°C
1.0		21°C
1.5		32°C
2.0		39°C
2.5		42°C
3.0		44°C
3.5		45°C
4.0		45°C

[3]

Experiment 2

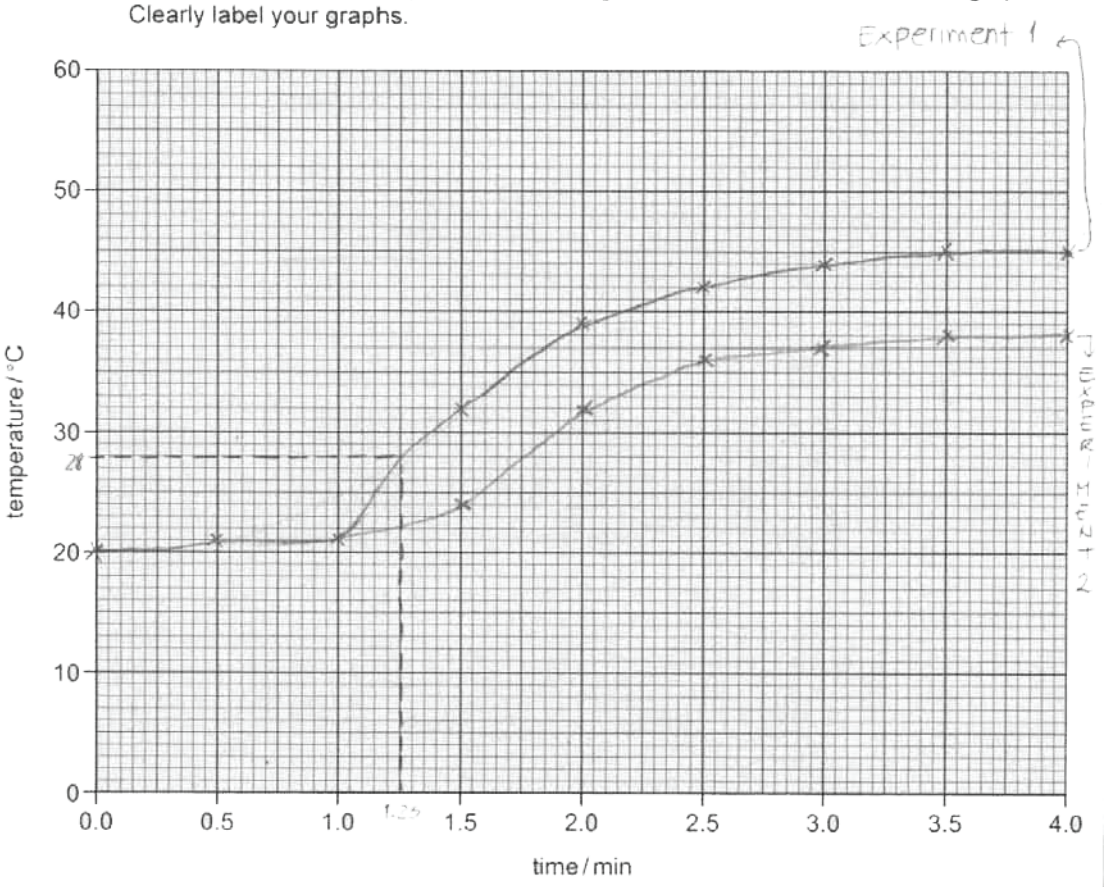
Experiment 1 was repeated using 5 g of iron powder instead of the zinc powder.

(b) Use the thermometer diagrams in the table to record the temperatures.

time / min	thermometer diagrams	temperature / °C
0.0		20°C
0.5		21°C
1.0		21°C
1.5		24°C
2.0		32°C
2.5		36°C
3.0		37°C
3.5		38°C
4.0		38°C

[3]

(c) Plot the results of both experiments on the grid below. Draw two smooth line graphs. Clearly label your graphs.



[5]

(d) **From your graph**, work out the temperature of the reaction mixture in Experiment 1 after 1 minute 15 seconds. Show clearly **on the graph** how you worked out your answer.

28 °C ..... [3]

(e) What type of chemical process occurs when zinc and iron react with aqueous copper(II) sulfate?

exothermic reaction ..... [1]

(f) **(i)** Compare the temperature changes in Experiments 1 and 2.

They are the same up to minute 1 [1]

(ii) Suggest an explanation for the difference in temperature changes.

The concentration of copper sulphate in experiment 1 was higher. [1]

(g) Explain how the temperature changes would differ in the experiments if 12.5 cm^3 of copper(II) sulfate solution were used.

Temperatures would be reduce by half because the half amount of copper (II) sulfate is used [2]

(h) Predict the effect of using lumps of zinc in Experiment 1. Explain your answer.

The reaction would be slower/and with low temperature because there is less surface area, therefore, less collisions. [2]

[Total: 21]

Examiner comment – grade C

The tables of results were correctly completed in **(a)** and **(b)**. Smooth line graphs were drawn as required in (c) and successfully used in **4(c)**. In **(f)**, the candidate was unable successfully to compare the temperature changes and then relate these to the different reactivity of the metals. Part **(g)** showed a lack of understanding that a smaller volume of solution used would result in a greater or faster temperature change.

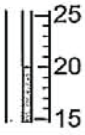
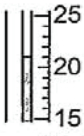
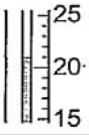
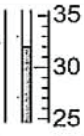
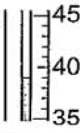
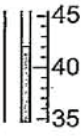
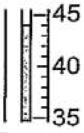
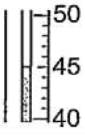
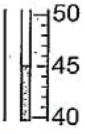
Example candidate response – grade E

4 A student investigated the reaction between aqueous copper(II) sulfate and two different metals, zinc and iron.
Two experiments were carried out.

Experiment 1
Using a measuring cylinder, 25 cm^3 of aqueous copper(II) sulfate was poured into a polystyrene cup. The temperature of the solution was measured. The timer was started and the temperature was measured every half a minute for one minute.

At 1 minute, 5 g of zinc powder was added to the cup and the mixture stirred with the thermometer. The temperature of the mixture was measured every half minute for an additional three minutes.

(a) Use the thermometer diagrams in the table to record the temperatures.

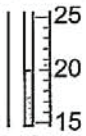
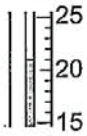
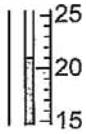
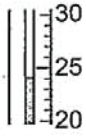
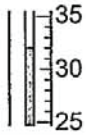
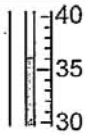
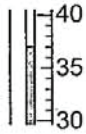
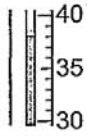
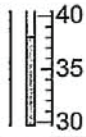
time / min	thermometer diagrams	temperature / °C
0.0		20
0.5		21
1.0		21
1.5		32
2.0		39
2.5		42
3.0		44
3.5		45
4.0		45

[3]

Experiment 2

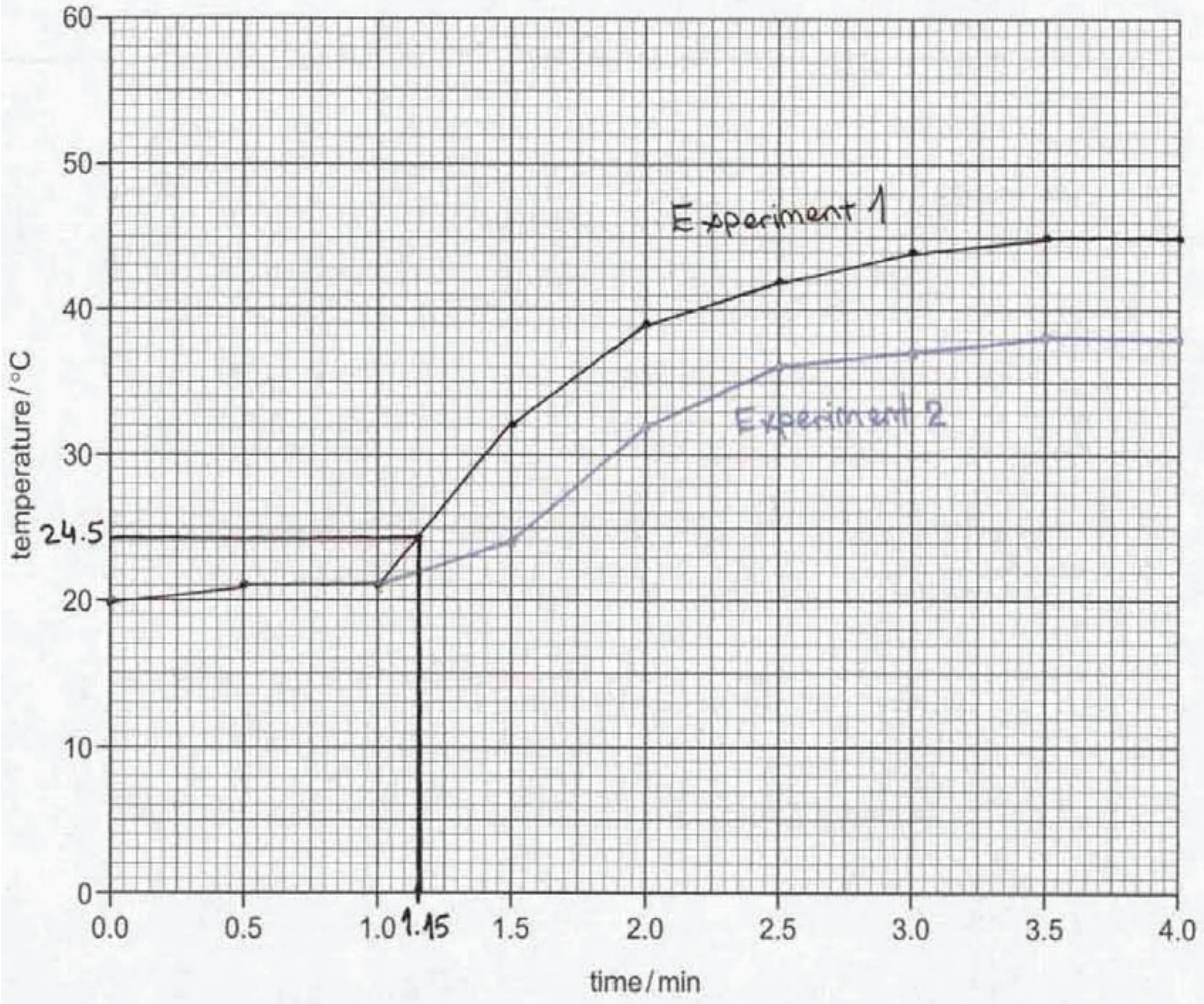
Experiment 1 was repeated using 5 g of iron powder instead of the zinc powder.

(b) Use the thermometer diagrams in the table to record the temperatures.

time / min	thermometer diagrams	temperature / °C
0.0		20
0.5		21
1.0		21
1.5		24
2.0		32
2.5		36
3.0		37
3.5		38
4.0		38

[3]

(c) Plot the results of both experiments on the grid below. Draw two smooth line graphs. Clearly label your graphs.



[5]

(d) **From your graph**, work out the temperature of the reaction mixture in Experiment 1 after 1 minute 15 seconds. Show clearly **on the graph** how you worked out your answer.

24.5 °C ..... [3]

(e) What type of chemical process occurs when zinc and iron react with aqueous copper(II) sulfate?

Temperature goes up. ..... [1]

(f) **(i)** Compare the temperature changes in Experiments 1 and 2.

The temperature change in Experiment 1 is greater. [1]

(ii) Suggest an explanation for the difference in temperature changes.

A combustion may be produced when they are mixed. This NaNO3 releases heat. [1]

(g) Explain how the temperature changes would differ in the experiments if 12.5 cm^3 of copper(II) sulfate solution were used.

The temperature ~~would~~ changes would be twice as higher.

[2]

(h) Predict the effect of using lumps of zinc in Experiment 1. Explain your answer.

[2]

[Total: 21]

Examiner comment – grade E

Tables of information were correctly completed in **(a)** and **(b)**. The results were plotted correctly in **(c)**, but the graphs were drawn with a ruler, i.e. 'dot to dot' and not smooth lines. The scale of the x axis was not understood in **(d)**. The term exothermic was not known in **(e)**. In **4(f)**, a confused answer related the temperature increase to a combustion reaction. The concept of metal reactivity was not known. Part **(h)** showed a lack of knowledge and understanding regarding the effect of surface area on the rate of a reaction.

Question 5

Mark scheme

5	(a)	(i)	**P**	colourless, no smell (1)	[1]
		(ii)	**P**	pH 1–3 (1)	[1]
	(b)	**P**		fizzes/effervescence/bubbles (1) lighted splint pops (1) **not** hydrogen	[2]
	(c)			white (1) precipitate (1)	[2]
	(e)			weak acid (1) ethanoic acid (2)	[2]
	(f)			water (1)	[1]

Example candidate response – grade A

5 Three different liquids **P**, **Q** and **R** were analysed.
P was an aqueous solution of sulfuric acid.
The tests on the liquids and some of the observations are in the following table.
Complete the observations in the table.

tests	observations
(a) (i) Appearance of the liquids.	**P** ..... [1] **Q** colourless, smell of vinegar **R** colourless, no smell
(ii) The pH of the liquids was tested using Universal Indicator paper.	**P** pH 2 ..... [1] **Q** pH 5 **R** pH 7
(b) A piece of magnesium ribbon was added to a little of each liquid. The gas given off by liquid **P** was tested.	**P** fast effervescense. Squeaky pop (hydrogen) [2] **Q** slow effervescence **R** no reaction
(c) To a little of liquid **P**, hydrochloric acid and aqueous barium chloride were added.	White precipitate [2]
(d) Liquid **R** was heated to boiling in a test-tube. A thermometer was used to record the constant temperature of the vapour produced.	temperature = 100 °C

(e) What conclusions can you draw about liquid **Q**?

Q is acidic and reasonably reactive [2]

(f) Identify liquid **R**.

Water (H_2O) [1]

[Total: 9]

Examiner comment – grade A

The qualitative analysis question shows that knowledge of acid properties and anion tests is good.
The candidate correctly described the reaction of magnesium with dilute sulfuric acid in **(b)** and the sulfate test in **(c)**. Liquid R was correctly identified in **(f)** from the physical property, but ethanoic acid was not recognised in **(e)**.

Example candidate response – grade C

5 Three different liquids **P**, **Q** and **R** were analysed.
P was an aqueous solution of sulfuric acid.
The tests on the liquids and some of the observations are in the following table.
Complete the observations in the table.

tests	observations
(a) (i) Appearance of the liquids.	**P** colourless [1] **Q** colourless, smell of vinegar **R** colourless, no smell
(ii) The pH of the liquids was tested using Universal Indicator paper.	**P** Ph 3 [1] **Q** pH 5 **R** pH 7
(b) A piece of magnesium ribbon was added to a little of each liquid. The gas given off by liquid **P** was tested.	**P** Burning splint was added and it relighted [2] **Q** slow effervescence **R** no reaction
(c) To a little of liquid **P**, hydrochloric acid and aqueous barium chloride were added.	White percipitate [2]
(d) Liquid **R** was heated to boiling in a test-tube. A thermometer was used to record the constant temperature of the vapour produced.	temperature = 100 °C

(e) What conclusions can you draw about liquid **Q**?

It's an alcohol [2]

(f) Identify liquid **R**.

Water [1]

[Total: 9]

Examiner comment – grade C

The qualitative analysis question demonstrated that the candidate had knowledge of pH in **(a)(ii)**, but was not able to apply it in **(e)**. A lack of detail and knowledge of the reaction of sulfuric acid with magnesium was evident in **(b)**. The response to **(e)** showed a lack of understanding of the chemistry of ethanoic acid.

Example candidate response – grade E

5 Three different liquids **P**, **Q** and **R** were analysed.
P was an aqueous solution of sulfuric acid.
The tests on the liquids and some of the observations are in the following table.
Complete the observations in the table.

tests	observations
(a) (i) Appearance of the liquids.	**P** COLOURLESS, TUNGENT SMELL. [1] **Q** colourless, smell of vinegar **R** colourless, no smell
(ii) The pH of the liquids was tested using Universal Indicator paper.	**P** PH 3 [1] **Q** pH 5 **R** pH 7
(b) A piece of magnesium ribbon was added to a little of each liquid. The gas given off by liquid **P** was tested.	**P** FAST EFFERVESCENCE LIQUID P GIVEN OFF [2] **Q** slow effervescence **R** no reaction
(c) To a little of liquid **P**, hydrochloric acid and aqueous barium chloride were added.	WHITE PPT, COLOURLESS [2]
(d) Liquid **R** was heated to boiling in a test-tube. A thermometer was used to record the constant temperature of the vapour produced.	temperature = 100 °C

(e) What conclusions can you draw about liquid **Q**?

IS AMMONIA. [2]

(f) Identify liquid **R**.

ALUMINIUM [1]

[Total: 9]

Examiner comment – grade E

The qualitative analysis question showed some knowledge of chemical tests. However, the answers to **(e)** and **(f)** showed an inability to relate the observations to relevant and meaningful conclusions.

Question 6

Example candidate response – grade A

6 Seawater contains sodium chloride and other salts.
Plan an experiment to find the mass of salts in 1 dm^3 of seawater.
You will be provided with a small bottle of seawater.
You should include details of the method and any apparatus used.
(1 dm^3 = 1000 cm^3)

first measure the amount of seawater by pouring it into a measuring cylinder; record this value. Then place the seawater into an evaporating basin and arrange so that it is over a bunsen burner (could use tripod; remember gauze on tripod and protective slate beneath bunsen burner). Heat until all moisture (evaporated) is gone and only salt remains. Then weigh the remaining salt using a balance; remember to [6]
around 100°C. Subtract the weight of the basin if it is weighed in), Record the measurement and convert to dm^3. [Total: 6]

Then ~~Subtract~~ do the calculations to find out how much the salts would weigh if you had used 1 dm^3 of seawater rather than the amount in the small bottle. (For example, if you used 10 cm^3 of seawater then convert to dm^3 ($10/1000 = 0.01 dm^3$) ~~times~~ multiply this amount to get 1 dm^3 ($0.01 \times 100 = 1 dm^3$). Then, finally, multiply the amount of salt you recorded at the end by the number you used to turn 0.01 dm^3 to 1 dm^3 (i.e. 100). This will give you the amount of salt you'd get in 1 dm^3 of seawater.)

Examiner comment – grade A

The planning exercise in Question 6 scored full credit. The candidate clearly described a practical method that would work. Full details of the apparatus to be used are given, e.g. measuring cylinder, evaporating dish, tripod, etc. Necessary measurements such as amount of sea-water and practical details, i.e. evaporate to dryness, are provided.

An unnecessary amount of information was given at the end of the answer detailing how to convert the mass of salts into that present in 1 dm^3 of sea-water.

A grade C candidate script is unavailable for this question.

Example candidate response – grade E

6 Seawater contains sodium chloride and other salts.
Plan an experiment to find the mass of salts in 1 dm^3 of seawater.
You will be provided with a small bottle of seawater.
You should include details of the method and any apparatus used.
(1 dm^3 = 1000 cm^3)

get the sea water ~~put the~~ it in a measuring cylinder and measure 1dm3. After that you filter then you heat it ~~with a bunsen burner~~ with a bunsen burner, until it boils. Be the water evaporate at 100° ~~degg~~. ~~Then filtrate~~ To filter before heating you must use a filter paper and a funnel.

[6]

[Total: 6]

Examiner comment – grade E

The planning exercise in Question 6 gained some credit. The idea of using a measuring cylinder to record the volume of the water and subsequent boiling of the water was realised. However, essential detail such as weighing the residue was omitted. The candidate mistakenly thought that a small bottle of water contained 1 dm^3 of water. The unnecessary filtering of the water showed more confusion.

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