CHEMISTRY

Paper 0620/11
Multiple Choice (Core)

Question Number	Key	Question Number	Key	Question Number	Key	Question Number	Key
1	B	11	A	21	B	31	C
2	C	12	B	22	A	32	D
3	D	13	B	23	B	33	B
4	B	14	A	24	B	34	D
5	A	15	B	25	A	35	C
6	A	16	C	26	A	36	C
7	B	17	D	27	D	37	B
8	D	18	C	28	A	38	D
9	C	19	D	29	D	39	A
10	C	20	C	30	C	40	D

General comments

This paper had a small number of candidate entries.

Candidates found **Questions 3**, **6**, **9**, **30** and **40** to have the least challenge. **Questions 1**, **7**, **15**, **22**, **26**, **27**, **38** and **39** were the most demanding. **Questions 4**, **8**, **16** and **31** showed the greatest discrimination between the candidates. Multiple completion questions, which require candidates to identify two or more correct statements were often poorly answered.

Significant gaps in knowledge were revealed by many of the questions that required recall of key syllabus statements.

Comments on specific questions

Question 1

Most candidates thought that the decane was solid and gave option **C**. Few candidates gave the correct answer with option **D** being the second most common answer.

Question 4

Candidates who performed less well overall were more likely to give any of the incorrect distractors, suggesting guessing.

Question 7

Many candidates identified that the halogen is diatomic. Others did not recognise the significance of the word 'compound' and so option **A** was a common answer. Overall, this question did not discriminate well between the candidates and the distribution of answers suggests guessing was common.

Question 8

Few candidates chose options **A** or **B**. Option **C** was a common incorrect response, where candidates confused the structures or diamond and graphite.

Question 10

Only a minority of candidates answered this correctly. Overall, the distribution of responses suggests guessing was common.

Question 15

Some candidates chose option **C**, suggesting that the colour of hydrated copper(II) sulfate is known but the full list of colours for anhydrous and hydrated copper(II) and cobalt(II) is less well known.

Question 16

This question on redox discriminated well. Candidates should recall that oxidation and reduction must occur as a pair. Candidates who performed less well overall tended to give option **A**.

Question 19

All candidates found this question difficult. Some confused the terms filtrate and residue and there was also evidence of guessing.

Question 22

The products of the reaction between sodium and water were not well recalled. The most common answer was option **C**, showing that more thought oxygen rather than hydrogen is a product.

Question 35

Some candidates chose option **D**, perhaps assuming that common bottled camping gas is natural gas.

Question 38

Few candidates answered this correctly. Many suggested option **C**, perhaps omitting the O–H bond which is a common omission when drawing organic structures. Option **B** was the most common answer.

Question 39

This question was poorly answered. Some chose option **B**, assuming that hydrogen is a product of the reaction. Candidates should note that on this syllabus, hydrogen is not commonly a product and only appears when one of the more reactive metals reacts. Others gave option **D**, showing confusion with litmus colours.

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Paper 0620/12
Multiple Choice (Core)

Question Number	Key	Question Number	Key	Question Number	Key	Question Number	Key
1	C	11	B	21	B	31	C
2	C	12	A	22	A	32	D
3	D	13	B	23	C	33	C
4	B	14	D	24	B	34	D
5	A	15	C	25	A	35	A
6	B	16	C	26	B	36	C
7	D	17	A	27	A	37	C
8	B	18	B	28	A	38	B
9	C	19	C	29	B	39	D
10	D	20	C	30	D	40	D

General comments

Overall, the paper showed a wide distribution of marks and gave clear discrimination between candidates. **Questions 1**, **3**, **4**, **5**, **23**, **28**, **36** and **39** had the least demand. Candidates found **Questions 7**, **12** and **20** to have the greatest demand. **Questions 15**, **22**, **33**, **37** and **40** showed the greatest discrimination between candidates.

Questions 11 and **12** on energy changes and **Questions 2** and **19** on practical chemistry were particularly poorly answered, especially by the weaker candidates. Colours of compounds and ion tests, **Questions 15** and **20**, were not well recalled.

Comments on specific questions

Question 2

Candidates commonly chose option **A**, which would allow measurements but not to the precision required by the question. A pipette would be required rather than a measuring cylinder.

Question 7

This question was not answered correctly by many candidates and there appeared to be a degree of guessing. Candidates should know the typical properties of ionic compounds and the meaning of chemical terms such as ‘volatility’.

Question 11

All options were chosen, with option **C** being the most common response. This suggests some misunderstanding of the term ‘exothermic’ and in the use of energy level diagrams.

Question 12

This question was very poorly answered. All three options were given in preference to the correct answer. Candidates should recall that combustion reactions are exothermic.

Question 13

Option **A** was a common incorrect response. Although the volume of acid may affect overall rate when the other reactant is in excess, it is not always correct that increasing the volume will increase the reaction’s rate.

Question 15

The colours of different metal compounds were not well recalled. Option **A** was a common incorrect response.

Question 19

Option **A** was chosen by candidates who performed less well overall. In preparations of salts, it is usual to add an excess of an insoluble oxide or carbonate to neutralise all the acid and to allow easy separation of the excess by filtration.

Question 20

This question on ion tests was not well answered. The distribution of responses suggest that most candidates were guessing.

Question 22

Candidates tended to confuse the reactivity trend of Groups I and VII in this question. The most common response was option **D**.

Question 33

Candidates are often able to complete balanced equations. This question appeared to be slightly more demanding than in the past and some candidates found it difficult. They were more likely to choose option **A**, ignoring either the oxygen in CO_2 or the H_2O from the equation.

Question 39

This was the best answered question on the paper. Nearly all candidates identified the correct catalyst for fermentation.

Question 40

Some candidates appeared to be guessing, although there was a slight preference for option **B**.

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Paper 0620/13
Multiple Choice (Core)

Question Number	Key
1	A
2	C
3	D
4	C
5	A
6	C
7	D
8	C
9	C
10	B

Question Number	Key
11	B
12	D
13	B
14	D
15	A
16	C
17	B
18	D
19	A
20	C

Question Number	Key
21	B
22	B
23	C
24	B
25	A
26	C
27	C
28	A
29	A
30	A

Question Number	Key
31	C
32	D
33	D
34	D
35	C
36	B
37	A
38	B
39	D
40	D

General comments

Candidates found **Questions 1**, **3**, **4**, **9** and **27** to have least demand and **Questions 20**, **29**, **35**, **37** and **38** to be more demanding.

Questions involving observations in practical chemistry or ion tests such as **Questions 15**, **20** and **29** were not well answered.

Comments on specific questions

Question 7

Most candidates chose option **A**. The next most common response was the correct answer, which suggests that candidates incorrectly assume that there is a double bond between chlorine molecules.

Question 10

This question required recall of the electrolysis products of aqueous sodium chloride. Most candidates chose option **D**. Candidates should recall that sodium could not be produced in the presence of water.

Question 15

Although the most common response was correct, some candidates chose option **C**, which is the incorrect way round for anhydrous and hydrated copper(II) sulfate.

Question 20

Recall of ion tests proved to be quite challenging. This question was one of the more demanding questions and some candidates chose any of the options, other than the correct answer.

Question 22

This question discriminated well between candidates. Some candidates chose options **C** or **D**, suggesting that some physical trends of the Group I elements were not well recalled.

Question 25

Few candidates chose options **C** or **D**, but some chose option **B**. Candidates should recall that pure metals will always react to form cations by losing electrons.

Question 26

A number of candidates chose option **A**. Candidates must take care when reading the information given in the stem to place the unfamiliar metal in the reactivity series.

Question 29

This question on the reaction of ammonium ions with hydroxide ions was not well answered. Candidates were more likely to suggest that sulfur dioxide would be produced in the reaction. Similarly to **Question 20**, basic ion tests were not well recalled.

Question 30

Candidates often find multiple completion questions more demanding. Options **B** and **C** were common incorrect answers. Candidates should recall that cracking of alkanes does not involve oxygen and so carbon dioxide would not form.

Question 32

Some candidates appeared to be guessing as the number choosing each option was almost the same.

Question 35

The syllabus statement that natural gas is mostly methane was not well recalled. The most common incorrect response was hydrogen, option **A**. Other candidates confused clean air with natural gas and gave option **D** as a common incorrect answer.

Question 37

Option **B** was the most common response. Candidates were confusing the formulae of ethane and ethene.

Question 38

Options **A** and **D** were common incorrect choices, where candidates confused addition with fermentation or ethane and ethene.

Question 40

Option **B** was a common answer, by those candidates who suggested nylon is a natural polymer.

CHEMISTRY

Paper 0620/21
Multiple Choice (Extended)

Question Number	Key	Question Number	Key	Question Number	Key	Question Number	Key
1	B	11	B	21	B	31	A
2	C	12	B	22	B	32	D
3	D	13	C	23	B	33	A
4	B	14	C	24	B	34	D
5	A	15	B	25	A	35	A
6	D	16	D	26	A	36	C
7	C	17	C	27	C	37	B
8	D	18	A	28	B	38	A
9	C	19	D	29	D	39	A
10	C	20	C	30	B	40	A

General comments

Overall, the candidates found this to be a challenging paper.

Candidates found **Questions 3**, **4**, **5**, **21** and **24** to be the easiest. **Questions 1**, **7**, **16**, **28** and **31** were found to be the most demanding. Redox chemistry was not well recalled in **Question 16**.

Comments on specific questions

Question 1

This question appeared to confuse many candidates and option **C** was the most common response.

Question 2

Candidates should make sure that the measurement apparatus is suitable for the precision of the measurement needed. In this question, 25.00 cm^3 could only be provided using a pipette and not a measuring cylinder. Option **A** was a common incorrect answer.

Question 6

Candidates who performed less well tended to give option **C**. This suggests that they did not use the stoichiometry shown by the equation and used a 1:1 ratio instead.

Question 7

This question was not well answered. Candidates confused bonding within molecules and attractive forces between molecules. Candidates should also recall that molecules have covalent bonds between their atoms. Options **A** and **B** were common incorrect answers.

Question 14

Relatively few candidates chose option **D**, but all the other options were equally likely to be given suggesting that candidates struggle to identify both the effect of temperature and the effect of pressure on a gaseous equilibrium.

Question 16

Redox chemistry was not well recalled. Overall, the distribution of answers suggests that many candidates were guessing.

Question 18

Candidates who performed less well were more likely to give any of the incorrect options suggesting that guessing was common.

Question 27

Option **B** was a common incorrect choice. These candidates assumed that aluminium did not react because it is an unreactive metal.

Question 28

The thermal decomposition products of metal nitrates was not well recalled. Most candidates gave options **C** or **D**, suggesting that they confused the acidic gas with the basic solid oxide.

Question 29

There was evidence of guessing in this question. Option **B** was the most common incorrect answer, suggesting that barrier methods of rust prevention are well known but sacrificial corrosion is not.

Question 31

The distribution of responses suggests many candidates were guessing on this question about the Contact process. Options **B** and **C** were the most common incorrect answers.

Question 33

Only a minority of candidates answered this question correctly. Candidates should read the question carefully to make sure that they understand what is being asked. Many candidates gave an answer which corresponded with substance R rather than substance Q. Of those that identified the correct number of carbons for substance Q, a third thought the product would also be an alkene, option **B**. To answer this question, candidates could write a chemical equation identifying R and then identify Q by balancing the number of atoms.

Question 35

Although the correct answer was more commonly given overall, some candidates gave option **B**, suggesting that the C=O present in the carboxylic acid was not well remembered.

Question 39

This question was not well answered. Option **B** was the most common response. Candidates should recall 'acid + base → salt + water' and recall that hydrogen is produced only when a reactive metal is used rather than a metal hydroxide.

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Paper 0620/22
Multiple Choice (Extended)

Question Number	Key
1	A
2	C
3	D
4	B
5	A
6	C
7	C
8	B
9	A
10	D

Question Number	Key
11	B
12	C
13	C
14	A
15	C
16	D
17	A
18	B
19	D
20	C

Question Number	Key
21	B
22	A
23	A
24	B
25	A
26	C
27	C
28	B
29	C
30	D

Question Number	Key
31	A
32	D
33	D
34	D
35	C
36	B
37	D
38	B
39	C
40	A

General comments

Overall the candidates found this to be an accessible paper. **Questions 1**, **3**, **4**, **5**, **8**, **21** and **29** were found to be easiest. Candidates found **Questions 7**, **16**, **22** and **31** more challenging. There was a wide distribution of marks, with some candidates doing particularly well. Candidates should take particular care when answering a question which includes the word 'not', **Question 30**. The word is written in bold to help the candidate take note.

Comments on specific questions

Question 2

Candidates should make sure that the measurement apparatus is suitable for the precision of the measurement needed. In this question, 25.00 cm^3 could only be provided using a pipette and not a measuring cylinder. Option **A** was a common incorrect answer.

Question 7

This question was not well answered. Candidates confused bonding within molecules and attractive forces between molecules. Candidates should also recall that molecules have covalent bonds between their atoms. Options **A** and **B** were common incorrect answers.

Question 13

A commonly chosen incorrect option was **A**. Candidates should take care to note whether the electrolysis occurs in a molten state or in water (aqueous). From their knowledge of the reactions of Group I elements with water, candidates should also be able deduce that sodium could not form in water.

Question 16

Candidates who performed less well were more likely to give any of the incorrect options, which suggests guessing. Many gave option **B**, suggesting confusion between the terms ‘reduction’ and ‘reducing agent’. The mnemonic OILRIG, ‘oxidation is loss’ and ‘reduction is gain’ of electrons could help candidates recall the transfer of electrons.

Question 20

Many candidates appeared to have guessed on this question. For these candidates, there was a slight preference for option **B**, where candidates have been unable to both interpret whether the reaction is endothermic or exothermic and how pressure affects the position of this equilibrium.

Question 22

Although most candidates answered this correctly, option **C** was a common error. Where information about compounds not found on the syllabus is given, candidates should take their time to read and understand the information before answering the question. Many candidates appeared to have guessed on this question.

Question 26

Some candidates incorrectly chose options **A** and **B**, showing confusion between the extraction of iron in the blast furnace and the extraction of aluminium by electrolysis.

Question 30

Candidates should take particular care when answering a question which includes the word ‘not’. The word is written in bold to help the candidate take note. Many candidates chose option **C**, which is a correct statement but not the answer to the question asked.

Question 31

Although there was a slight preference for the correct answer, the overall distribution suggests that many candidates were guessing. All the options were frequently chosen.

Question 36

Some candidates chose option **A**. Choosing the incorrect chemical formula for an organic compound is a common mistake. Candidates should take particular care when writing formulae of alkanes and alkenes.

Question 38

Most candidates were able to recall that unsaturated hydrocarbons can be manufactured by cracking. A significant minority chose option **C**, confusing the colour observed during the reaction of bromine with an unsaturated compound.

CHEMISTRY

Paper 0620/23
Multiple Choice (Extended)

Question Number	Key	Question Number	Key	Question Number	Key	Question Number	Key
1	B	11	B	21	B	31	D
2	C	12	B	22	D	32	D
3	D	13	C	23	D	33	C
4	C	14	B	24	B	34	D
5	A	15	B	25	A	35	C
6	C	16	D	26	C	36	B
7	C	17	D	27	C	37	D
8	A	18	D	28	B	38	A
9	A	19	A	29	A	39	B
10	B	20	C	30	D	40	A

General comments

Overall, the candidates found this to be an accessible paper. **Questions 3**, **4**, **5**, **6**, **21**, and **31** were found to be the easiest and **Questions 28** and **37** were found to be the hardest. There was a wide distribution of marks, with some candidates doing particularly well.

Comments on specific questions

Question 2

Candidates should make sure that the measurement apparatus is suitable for the precision of the measurement needed. In this question, 25.00 cm^3 could only be provided using a pipette and not a measuring cylinder. Option **A** was a common incorrect answer.

Question 7

This question was not well answered. Candidates confused bonding within molecules and attractive forces between molecules. Candidates should also recall that molecules have covalent bonds between their atoms. Options **A** and **B** were common incorrect answers.

Question 14

Although this question was well answered overall, some candidates chose option **A**. For this response, the candidates recognised two common fuels but did not recognise the need for oxygen.

Question 15

Candidates who performed less well were more likely to give option **D**, which correctly identifies the effect of temperature on reaction rate but incorrectly describes the change to the position of equilibrium.

Question 16

Many candidates gave any of the incorrect options, suggesting guessing. Option **B** was a popular incorrect choice, suggesting confusion between the term ‘reduction’ and the term ‘reducing agent’. The mnemonic OILRIG, ‘oxidation is loss’ and ‘reduction is gain’ of electrons could help candidates recall the transfer of electrons.

Question 18

Some candidates appeared to be guessing.

Question 28

This question on the source of oxides of nitrogen was one of the least well answered questions. Option **D** was a popular incorrect answer as candidates thought that the nitrogen came from petrol rather than the air.

Question 30

This was a relatively demanding question and many candidates appeared to be guessing. Option **A** was chosen by many candidates. These candidates showed some chemical knowledge because hydrogen is produced in the electrolysis of water, but it is not the source of hydrogen for the Haber process.

Question 32

Some candidates gave option **A**, perhaps confusing the question with the release of ammonia from ammonium using an alkaline solution.

Question 35

The syllabus statement that natural gas is mostly methane was not well recalled. The most common responses were, option **A**, hydrogen and option **D**, nitrogen where candidates confused natural gas with clean dry air.

Question 37

This question was one of the least well answered questions. Candidates who performed less well overall tended to choose option **C**, identifying structural isomerism but incorrectly assuming that the two compounds will have similar chemical properties. Other candidates tended to favour option **A** as the most common incorrect answer. These candidates identified that the compounds have the same molecular formula but did not recognise structural isomerism.

Question 38

Some candidates chose option **B**. Candidates would be advised to make a list linking the homologous series to the reactions they are associated with. On this syllabus, hydrogenation is only found in the conversion of alkanes to alkenes.

Question 39

Many candidates gave option **C**, with the correct answer being the least popular choice. The main confusion appears to be that these candidates thought that proteins are formed by addition rather than condensation polymerisation.

CHEMISTRY

Paper 0620/31
Theory (Core)

Key messages

- Some candidates would benefit by improving their knowledge of specific chemical terms and processes.
- Many candidates need more practice in analysing the stem of a question.
- Many candidates need more practice in memorising chemical tests for specific ions.
- Interpretation of data from tables and completion of chemical equations was generally well done.

General comments

Many candidates tackled this paper well, showing a good knowledge of core Chemistry. The standard of English was generally good. Few of the questions were left unanswered.

Some candidates need more practice in writing answers with the correct amount of detail using or explaining specific chemical terms. For example, in **Question 1(c)** some candidates did not give a reason for the basicity of magnesium oxide. In **Question 3(b)(ii)**, many gave generalised explanations of reduction with no reference to the equation. In **Question 5(c)**, attempts to describe the meaning of the term unsaturated hydrocarbon were often hampered by vague statements. In **Question 7(a)(ii)**, many candidates muddled the separation of particles with the arrangement or movement of the particles or wrote about bulk properties rather than particle properties. Many candidates need practice in writing more specifically when answering questions about environmental chemistry. For example, in **Question 7(b)(i)** (sources of oxides of nitrogen), many candidates suggested 'factories' or 'fossil fuels' without any further qualification. In **Question 7(b)(ii)**, many candidates wrote vague statements about 'rotting' or 'destroying' buildings rather than using specific terms such as chemical erosion or corrosion. Some candidates need to revise chemical nomenclature. The suffix ending of binary salts, -ide, was often written as -ine.

Some candidates need more practice in analysing the stem of a question to pick out the essential words needed to answer the question. In **Question 1(a)**, many candidates did not seem to distinguish between elements and compounds. In **Question 3(e)**, some candidates gave chemical properties rather than physical properties or did not heed the word 'other' in the stem of the question and gave 'shiny' or 'conducts electricity' as an answer. A similar omission occurred in **Question 4(f)(i)**, where many candidates repeated the 'polymers' in the stem of the question. In **Question 7(a)**, some candidates did not use the kinetic particle theory as instructed or thought that separation referred to physical separation of mixtures in terms of distillation or filtration. In **Question 7(b)(ii)**, some candidates wrote about the effect of oxides of nitrogen on health rather than on buildings.

Some candidates would benefit from further revision of specific topic areas such organic chemistry (**Question 5**), physical properties (**Questions 3(e)** and **6(a)**) and particle theory (**Question 7(a)(ii)**).

Many candidates need to revise qualitative tests for specific ions and molecules. The answers to the questions about the test for chloride ions (**Question 2(b)**) and the test for nitrate ions (**Question 6(b)**) were not well known.

Many candidates were able to extract information from tables and graphs, balance symbol equations and undertake simple chemical calculations.

Comments on specific questions

Question 1

Many candidates identified at least two of the formulae correctly in **(a)**. Others seemed to guess the answers as a wide range of incorrect answers was seen; many candidates did not distinguish between the terms element and compound. In **(b)**, many candidates were able to complete the dot-and-cross diagram for ammonia correctly. In **(c)**, few candidates gave a suitable reason why magnesium oxide is a basic oxide.

(a) (i) A minority of the candidates recognised copper(II) sulfate. A wide variety of incorrect answers was seen, cobalt chloride being the commonest incorrect answer.

(ii) Some candidates identified calcium carbonate. The commonest incorrect answers were copper(II) sulfate, aluminium chloride or sodium chloride.

(iii) This was the best answered part of question 1**(a)**. The commonest incorrect answers were oxygen or carbon dioxide, which is not an element.

(iv) Some candidates identified the compound that contains an ion with a single positive charge. The commonest incorrect answers were $MgCl_2$ or other chlorides. A minority of the candidates suggested the formulae of elements.

(v) A few candidates identified ammonia as a compound that is soluble in water and formed an alkaline solution. The commonest incorrect answers were calcium carbonate or sodium chloride. Many candidates appeared to guess the answer, as evidenced by the wide range of incorrect answers seen.

(b) Common errors were to miss out the non-bonding electrons on the nitrogen or to add non-bonding electrons to the hydrogen atom. A considerable number of candidates drew either one or three pairs of bonding electrons.

(c) This was the least-well answered part of **Question 1**. Many candidates thought that magnesium oxide was an acidic oxide. The reason was often not specific enough. The best answers referred to 'magnesium is a metal' or 'metal oxides are basic'. Others gave vague answers, either referring to magnesium oxide being a basic compound or trying to relate basicity to chemical reactivity.

Question 2

Some candidates gave good answers to **(a)(i)**, **(a)(iii)**, **(c)(ii)** and **(d)**. In **(a)(ii)**, many did not use the information in the table and wrote only the name of one of the ions. Very few candidates knew the test for chloride ions in **(b)** and in **(c)(i)** many candidates put a ring around the –OH of the carboxylic acid group.

(a) (i) Nearly all the candidates selected the sodium ion as having the highest concentration in the rainwater. The commonest error was to suggest 'chloride' through not reading the question carefully enough.

(ii) A few candidates gave the correct name 'ammonium sulfate'. One common error was 'ammonia sulfate'. Others did not use the information in the table and gave the name of made-up nitrogen compounds such as 'nitrogen oxygen sulfate' or 'sulfur nitroxide'.

(iii) The majority of candidates did the calculation correctly using simple proportion.

(b) Very few candidates knew the test for chloride ions. Flame tests were often suggested or reaction with sodium hydroxide or with acids. Some candidates realised that a white precipitate would be formed but the test regent was invariably incorrect. Yellow or red-brown precipitates were often suggested. A considerable minority of the candidates suggested tests which were more appropriate for gases.

(c) (i) Most candidates put a circle around the OH of a COOH group or around all of the COOH group. Many candidates did not appear to know the meaning of a functional group because they included large portions of the carbon chain within their ring.

(ii) Many of the candidates gave the correct molecular formula. The commonest errors were to write formulae which were partly structural or to miscount the number of hydrogen or oxygen atoms.

(d) This was the best answered part of this question. Most of the candidates calculated the relative molecular mass correctly. The commonest errors related to misreading the formula of compound **A**, six hydrogen or two oxygen atoms being used in the calculation.

Question 3

This was one of the best-answered questions on the paper. Many candidates performed well in **(b)(i)**, **(c)(ii)** and **(d)** but found **(b)(ii)** more challenging. In **(c)(i)** and **(d)(ii)**, a wide variety of incorrect answers was seen. In **(e)**, some candidates did not read the stem of the question properly and suggested 'conducts electricity'.

(a) A wide variety of incorrect answers was seen, **D** being the commonest.

(b) (i) Nearly all the candidates balanced the equation correctly. The commonest error was to suggest 2CO.

(ii) The best answers stated that 'oxygen is removed from iron oxide'. The majority of candidates gave answers which were too vague and did not refer to the equation, e.g. 'oxygen is removed'. Some candidates referred to the iron (which is on the right-hand side of the equation) rather than the iron oxide (which is on the left). Others just wrote about carbon gaining oxygen rather than the iron oxide losing oxygen.

(c) (i) Some candidates realised that calcium oxide or carbon dioxide were formed but few suggested both products. Common errors included 'calcium' instead of calcium oxide and 'carbon monoxide', 'water' or 'oxygen' instead of carbon dioxide.

(ii) Most candidates realised that the slag floated on top of the iron. Some candidates wrote about properties other than density, e.g. 'iron is a metal and conducts but slag does not conduct'. A significant number of candidates did not respond to this question.

(d) (i) Many candidates realised that acidic gases react with basic oxides. Fewer recognised that oxygen is blown through molten iron in steelmaking. 'Methane' or 'nitrogen' were common incorrect answers.

(ii) A minority of candidates gave a suitable use for mild steel. Many confused mild steel with stainless steel and gave answers such as 'for cutlery' or 'for surgical knives'.

(iii) Most of the candidates deduced the number of electrons, neutrons and protons correctly. The commonest errors related to the number of neutrons; the number of neutrons often being given as 53 (the mass number) or 24 (with the number of protons then being given as 29). The number of electrons was occasionally given as a slightly lower or higher value than 24, possibly due to confusion between ions rather than atoms.

(e) The best answers focussed on malleability, ductility and conduction of heat. Many candidates did not read the stem of the question properly and suggested 'good conductor of electricity' or 'shiny', which were mentioned in the stem. Others suggested chemical properties instead of physical properties. Others gave properties which are not characteristic of all metals, e.g. high density.

Question 4

This was a well-answered question on the paper. Parts **(a)(i)**, **(c)(i)** and **(c)(iii)** were particularly well answered. A minority of the candidates gave a suitable observation for the reaction of rubidium with water in **(a)(ii)**. In **(c)(ii)**, most suggested a neutral or an acidic pH value.

(a) (i) Most candidates completed the table correctly; the commonest errors being to give too high a value for either the melting point of rubidium or the density of lithium.

(ii) The best answers referred to 'very rapid bubbling' or 'slight explosion'. Many candidates did not look at the trend and repeated either 'rapid bubbling' (which was the observation for potassium) or 'explodes' (which was the observation for caesium). Candidates should be encouraged to look at the trends and give a description that follows the trend but does not replicate the other observations exactly.

(b) Some candidates gave the correct electronic structure of potassium as 2,8,8,1 or described this in words or as a diagram. Others gave 2,8,8 or 2,6,8,1 or wrote 19; the total number of electrons.

(c) (i) Most candidates recognised that hydrogen pops with a lighted splint. The commonest error was to suggest 'oxygen'.

(ii) Some candidates recognised that aqueous lithium hydroxide is alkaline and so has a pH which is above pH 7. The majority suggested a neutral or an acidic pH value.

(iii) Most candidates were able to balance the equation correctly. The commonest errors were 2(Li) or 3(Li).

Question 5

This was the least-well answered question on the paper. Some candidates were able to deduce the homologous series in **(a)** and draw the structure of ethene in **(b)**. Fewer were able to explain the term unsaturated compound in **(c)** or deduce which compound reacts with sodium hydroxide in **(d)**. In **(e)**, few candidates realised that both carbon dioxide and water are formed by the complete combustion of a hydrocarbon. In **(f)(ii)**, only a minority of the candidates were able to describe a use of *Terylene*.

(a) Some candidates named the homologous series of alkenes and alkanes correctly. The commonest errors were to name specific compounds, e.g. 'propene', 'propane' or 'ethene' or to confuse alkenes with alkanes. A considerable minority suggested 'alcohols' for the alkene structure. A significant number of candidates did not respond to this question.

(b) The best answers drew the structure of ethene showing all the atoms and all the bonds. The commonest errors in drawing this structure were the omission of a hydrogen atom, drawing extra hydrogen atoms on one or both carbon atoms, or drawing ethane. Many candidates drew the structure of ethene but with a C–C bond.

(c) The best answers referred to double bonds between the carbon atoms. Most candidates wrote answers which, although carbon atoms were mentioned, were too vague, e.g. 'it is unsaturated because of the bond between the carbon atoms'. Other candidates wrote vague statements about the carbon atoms 'not being full'.

(d) Many candidates suggested that the alkene or the alkane reacted with aqueous sodium hydroxide. Those who correctly selected carboxylic acids, rarely gave an answer in terms of acids reacting with bases / alkalis. A significant number of candidates did not respond to this question.

(e) Some candidates realised that the products of complete combustion of a hydrocarbon are carbon dioxide and water; most only chose one of these products. The commonest errors were hydrogen instead of water or incorrect oxidation products such as 'ethane oxide'. Others gave products containing elements which did not appear in the reactants, e.g. 'sulfur dioxide' or ignored the term complete combustion and suggested carbon monoxide.

(f) (i) This was the best-answered part of this question. Many candidates identified 'monomers'. The commonest errors were to suggest 'polymers', despite the term being present in the stem of the question, or 'alkanes'. A significant number of candidates did not respond to this question.

(ii) Few candidates gave a suitable use for *Terylene*. Many candidates just mentioned 'for plastics' rather than giving a specific use. A significant number of candidates did not respond to this question.

Question 6

In **(a)**, some candidates described the physical properties of sodium bromide and graphite correctly. Others either gave answers which were too vague or bore no relation to the properties requested. A minority of the candidates identified the substance produced at the negative electrode in **(b)(i)**. The majority of candidates completed the word equation in **(c)(i)** correctly. Fewer gave a suitable explanation for the lack of reactivity between sodium chloride and bromine in **(c)(ii)**.

(a) Some candidates described the physical properties of sodium bromide and graphite correctly. Others either gave answers that were too vague or bore no relation to the properties requested. The term volatility was not well understood and many candidates thought that volatile compounds have high boiling points. Many candidates realised that potassium iodide is soluble in water. Fewer realised that bromine is insoluble. Many candidates suggested, incorrectly, that solid sodium bromide conducts electricity. Others thought that graphite does not conduct. A considerable number of candidates did not understand the question and wrote about solids, liquids and gases or their properties. Others wrote vague comparative answers referring to 'more soluble' or 'less volatile'.

(b) The minority of candidates recognised that hydrogen is produced at the negative electrode when dilute sulfuric acid is electrolysed. Many suggested 'sulfur'. Some misread the question and chose 'sodium' or 'bromine'. Others suggested incorrect answers such as 'carbon dioxide' or 'oxygen'.

(c) (i) Most of the candidates were able to name the products of the reaction between sodium bromide and chlorine. A common error was to give incorrect suffixes: chloride instead of chlorine and sodium bromine instead of sodium bromide. Other candidates suggested bromine chloride as a product, occasionally accompanied by hydrogen.

(ii) Few candidates wrote about the greater reactivity of chlorine compared with bromine. Most candidates either compared the reactivity of the halogen with the halides or compared it with sodium or with sodium compounds. Another common error was to compare the position of the halogens in the group without mentioning relative reactivity. A considerable number of candidates did not respond to this question.

Question 7

Most candidates were able to state the change of state from gas to liquid in **(a)(i)**. In **(a)(ii)**, many candidates confused the separation of the particles with the arrangement of the particles. The pollutant question about oxides of nitrogen in **(b)** was generally answered vaguely. In **(c)(ii)**, the test for nitrate ions was not well known despite the scaffolding provided. Better performing candidates correctly named the products in **(c)(ii)**; others need more revision about the reactions of acids.

(a) (i) Most candidates were able to state the change of state from gas to liquid. A few candidates suggested melting or gave answers relating to particle theory.

(ii) Many candidates confused the separation of the particles with the arrangement of the particles. Others wrote about the motion of particles when answering the question about the separation of particles. Many responses were too vague or did not specify whether the answer referred to the gas or to the liquid. Examples of answers which gained no credit included, 'the particles in the liquid are less packed' and 'the separation is less in liquid than in gas'. Candidates should note that the answer 'they are separated' is not sufficient because the word separation is present in the stem of the question. Others wrote about the bulk properties of solids and gases rather than writing about particles. A small number of candidates ignored the word particles and wrote about methods of separating mixtures, e.g. 'use distillation'. The question about the motion of the particles was generally better answered, although some candidates wrote about motion as well as separation.

(b) (i) The best answers referred to car exhausts. Many candidates wrote answers which were too vague to be awarded credit, e.g. 'factories', 'fossil fuels' or 'dead animals'.

(ii) Some candidates suggested a suitable effect of acid rain on buildings. Others did not read the stem of the question carefully enough and gave the effects on health. Many candidates wrote vague answers such as 'pollutes the air', 'it rots them' or 'it destroys them'.

(c) (i) Better performing candidates knew the test for nitrate ions. Others seemed to guess the reagents to be added and the gas evolved because a wide range of incorrect answers was given. 'Sulfate', 'ammonia' and 'chloride' were often seen instead of (sodium) hydroxide. 'Copper' or 'iron' were seen in place of aluminium and a variety of incorrect answers were seen in place of ammonia; many of them not on the list

(ii) Better performing candidates tended to correctly name the products. The commonest errors for calcium nitrate were 'calcium', 'calcium oxide' or 'calcium nitrate oxide'. 'Hydrogen' was often written instead of water or carbon dioxide. A minority of the candidates suggested 'oxygen'. A considerable number of candidates did not respond to this question.

Question 8

This was the best answered question on the paper, with many candidates performing well in **(a)**, **(c)** and **(d)(i)**. In **(b)**, many candidates drew the line for the final volume at 39 cm^3 and/or drew the initial gradient less steep. In **(d)(ii)**, many candidates incorrectly thought that larger pieces of catalyst of the same mass would increase the rate of reaction.

(a) (i) Nearly all the candidates correctly deduced the volume of oxygen released when the reaction is complete. A few candidates did not read the values on the grid correctly.

(ii) Nearly all the candidates deduced the volume of oxygen released after 50 s correctly.

(b) Many candidates drew the line for the final volume at 39 cm^3 and/or drew the initial gradient less steep. Others drew a steeper gradient which hit the original line on the curve at 60–80 s rather than levelling off before about 100 s. A few candidates did not credit for the initial gradient because their line followed the original line for more than 5 small squares.

(c) Most of the candidates deduced the changes in rates correctly. The commonest errors were to comment on time taken for the reaction to finish, rather than rate or to refer to a rate increase when the reaction was carried out in the absence of an enzyme.

(d) (i) Most of the candidates deduced the correct order of catalytic activity. The commonest error was to reverse the order completely.

(ii) The best answers included a reason in terms of surface area. Many candidates did not gain credit because they thought that larger pieces of catalyst of the same mass would increase the rate of reaction.

CHEMISTRY

Paper 0620/32
Theory (Core)

Key messages

- Some candidates would benefit by improving their knowledge of specific chemical terms and processes.
- Many candidates need more practice in analysing the stem of a question.
- Many candidates need more practice in memorising chemical tests for specific ions and unsaturated compounds.
- Interpretation of data from tables and completion of chemical equations was generally well done.

General comments

Many candidates tackled this paper well, showing a good knowledge of core Chemistry. The standard of English was generally good. Few of the questions were left unanswered.

Some candidates need more practice in writing answers with the correct amount of detail using or explaining specific chemical terms. For example, in **Question 1(c)** some candidates did not give a reason for the basicity of calcium oxide. In **Question 4(b)(ii)**, many wrote answers which did not refer to the numbers of protons and neutrons. In **Question 6(a)**, attempts to describe the physical properties were often hampered by vague statements. In **Question 7(a)**, many candidates confused the arrangement and separation of particles with the movement of particles or wrote about bulk properties rather than particle properties. Many candidates need more practice in writing definitions. For example, in **Question 3(c)** many candidates had difficulty in explaining the term decomposition and in **Question 5(f)(i)** many candidates wrote vague statements about polymers. In several places in the paper some candidates wrote about elements and compounds indiscriminately. For example, in **Question 3(c)**, when describing thermal decomposition, many candidates wrote about breakdown of elements rather than breakdown of compounds. Other candidates need to revise chemical nomenclature. The suffix ending of binary salts, -ide, was often written as -ine.

Some candidates need more practice in analysing the stem of a question to pick out the essential words needed to answer the question. In **Question 1(a)**, many candidates did not seem to distinguish between elements and compounds. In **Question 2(a)(ii)**, some candidates gave formulae rather than a name. In **Question 3(c)(i)**, some candidates wrote a formula instead of the number of carboxylic acid groups. In **Question 3(f)**, some candidates gave chemical properties rather than physical properties or did not heed the word 'other' in the stem of the question and gave 'good conductor of heat' or 'good conductor of electricity' as an answer. A similar omission occurred in **Question 7(c)(ii)**, where many candidates repeated the 'sulfur dioxide' in the stem of the question. In **Question 5(f)(iii)**, many candidates described the meaning of non-biodegradable rather than describing a pollution problem. In **Question 6(b)(iii)**, some candidates did not refer to relative reactivity and in **Question 7(a)**, some candidates did not use the kinetic particle theory as requested.

Some candidates would benefit from further revision of specific topic areas such organic chemistry (**Question 5**), physical properties (**Questions 3(f)** and **6(a)**) and particle theory (**Question 7(a)**).

Many candidates need to revise qualitative tests for specific ions and molecules. The answers to the questions about the test for sulfate ions (**Question 2(b)**) and the test for unsaturated organic compounds (**Question 6(c)**) were not well known.

Many candidates were able to extract information from tables and graphs, balance symbol equations and undertake simple chemical calculations.

Comments on specific questions

Question 1

Many candidates identified at least two of the formulae correctly in **(a)**. Others seemed to guess the answers as a wide range of incorrect answers was seen; many candidates did not distinguish between the terms element and compound. In **(b)**, many candidates were able to complete the dot-and-cross diagram for water correctly. In **(c)**, few candidates gave a suitable reason why calcium oxide is a basic oxide.

(a) (i) A minority of the candidates recognised methane as the main component of natural gas. A wide variety of incorrect answers was seen; many of these not being gases.

(ii) This was the best answered of the part **(a)** questions. The majority of candidates correctly identified chlorine. The commonest incorrect answer was 'SO_2', which is a compound and not an element.

(iii) Some candidates recognised that chlorine bleaches litmus paper. A wide variety of incorrect answers was seen, many of these not being elements.

(iv) Some candidates identified the compound that contains an ion with a single negative charge. The commonest incorrect answers were CaO, MgO or $CaCO_3$. A considerable number of candidates suggested the formulae of molecular compounds.

(v) A small majority of the candidates identified a hydrocarbon. The commonest incorrect answers were C_2H_5OH (confusion with fermentation) or water. Others suggested inorganic compounds such as '$NaCl$' or 'MgO'.

(b) Common errors were to miss out the non-bonding electrons on the oxygen, to give three pairs of non-bonding electrons rather than two and/or to add non-bonding electrons to the hydrogen atom. A considerable number of candidates drew either one or three pairs of bonding electrons.

(c) This was the least-well answered part of **Question 1**. Many candidates thought that calcium oxide was an acidic oxide. The reason was often not specific enough. The best answers referred to 'calcium is a metal' or 'metal oxides are basic'. Others gave vague answers, either referring to calcium oxide being a basic compound or trying to relate basicity to chemical reactivity.

Question 2

Some candidates gave good answers to **(a)(i)**, **(a)(iii)** and **(c)(ii)**. In **(a)(ii)**, many did not use the information in the table and wrote only the name of one of the ions. Very few candidates knew the test for sulfate ions in **(b)**. In **(c)(i)**, many candidates did not read the stem of the question correctly and gave formulae.

(a) (i) Most candidates selected the silicate ion as having the lowest concentration. The commonest error was to suggest 'nitrate' through not reading all the way down the table. Few selected the positive ion rather than the negative ion.

(ii) Some of the candidates gave the correct name 'sodium nitrate'. Others just gave the name of one of the ions or separated them, e.g. 'sodium ions and nitrate' rather than giving the name of the compound as a whole. A few candidates wrote the formula instead of the name.

(iii) Most of the candidates did the calculation correctly using simple proportion.

(b) Very few candidates knew the test for sulfate ions. Flame tests were often suggested or reaction with sodium hydroxide or silver nitrate. Some candidates realised that a white precipitate would be formed but the test regent was invariably incorrect. Green, blue or red-brown precipitates were often suggested. A considerable minority of the candidates suggested tests which were more appropriate for gases. A considerable proportion of the candidates did not respond to this question.

(c) (i) Many candidates counted the number of carboxylic acid groups correctly. The commonest errors being two or six. Others did not read the stem of the question correctly and gave formulae, usually incorrect, such as 'C_2OOH'.

(ii) Most of the candidates calculated the relative molecular mass correctly. The commonest errors related to misreading the formula of citric acid, 6 hydrogen or 6 oxygen atoms being used in the calculation.

Question 3

This was the best-answered question on the paper. Many candidates performed well in **(b)(i)**, **(d)**, **(e)** and **(g)**. In **(a)**, some candidates did not know the name of the main ore of iron or wrote a name which was too far from the correct one. In **(c)**, many candidates defined the term thermal, but few gave a suitable description for the term decomposition. In **(f)**, many candidates did not read the stem of the question properly and suggested 'good conductor of heat' or 'good conductor of electricity', which were mentioned in the stem.

(a) Some candidates gave a spelling of hematite which was sufficiently phonetic to gain credit. Others gave spellings such as 'hamide' or 'haemate', which were too far from the correct spelling. Another common error was to suggest 'iron ore', despite 'ore of iron' being in the stem of the question. Others gave names of compounds such as 'iron oxide' or made-up names such as 'ironite'.

(b)(i) Most of the candidates were able to balance the equation correctly. The commonest errors were to write 2CO or 6CO.

(ii) Many candidates gave a suitable definition of reduction. The commonest errors arose when candidates tried to write a definition in terms of electrons, the incorrect answer 'loss of electrons' being frequently seen. Some candidates disadvantaged themselves by writing conflicting statements such as 'loss of oxygen and electrons'.

(c) Many candidates defined the term thermal correctly. Others gave rather vague answers referring to heat loss or contradictory answers referring to loss and gain of heat. Fewer candidates gave a suitable description for the term decomposition, with many spoiling their answers by suggesting 'breakdown of elements' or the vague 'breakdown of particles'.

(d)(i) Most candidates gave a suitable use for stainless steel. The commonest incorrect answers referred to structures made from mild steel, e.g. car bodies or bridges. Candidates should be encouraged to use the examples mentioned in the syllabus.

(ii) The majority of candidates gave a suitable advantage of using stainless steel in terms of improved strength, hardness or resistance to corrosion. A significant minority of the candidates suggested that stainless steel is softer or more ductile than iron.

(e) Most of the candidates deduced the number of electrons, neutrons and protons correctly. The commonest errors related to the number of neutrons; the number of neutrons often being given as 57 (the mass number) or 26 (with the number of protons then being given as 31). The number of electrons was occasionally given as 27 or 25, possibly due to confusion with ions rather than atoms.

(f) The best answers focussed on malleability, ductility and lustre. Many candidates did not read the stem of the question properly and suggested 'good conductor of heat' or 'good conductor of electricity' which were mentioned in the stem. Others suggested chemical properties instead of physical properties. Others gave properties which are not characteristic of all metals, e.g. high density.

(g) Most candidates knew that air and water are needed for iron to rust. The commonest errors were to suggest hydrogen instead of water or carbon dioxide instead of oxygen / air.

Question 4

Parts **(a)(i)** and **(c)(i)** were generally well answered. A minority of the candidates were able to give a suitable observation for the reaction of lithium with water in **(a)(ii)** and hardly any gave a suitable reason for a potassium ion having a single positive charge in **(b)(ii)**. In **(c)(ii)**, some candidates recognised that aqueous sodium hydroxide is alkaline and so has a pH which is above pH 7. A majority suggested a neutral or an acidic pH value.

(a)(i) Most candidates deduced the melting point and density correctly. The commonest errors were to suggest a melting point too close to or just above 98°C or too close to or just below 39°C.

(ii) The best answers referred to 'slow bubbling' or 'bubbles produced slower than sodium'. Many candidates did not look at the trend and either repeated 'rapid bubbling' (which was the observation for sodium) or got the trend the wrong way round and suggested 'coloured flame' or 'slight explosion'.

(b) (i) Some candidates gave the correct electronic structure of sodium as 2,8,1 or described this in words or as a diagram. Others gave 2,8, 2,8,2 or 2,6,3. A considerable minority wrote 11, the total number of electrons, or 23, the relative atomic mass.

(ii) The best answers referred to the potassium ion having one more proton than electron or having 19 protons and 18 electrons. Most candidates did not gain credit because they either wrote about the reactivity of potassium or referred to potassium ions, rather than potassium atoms losing one electron. Others either did not specify the number of electrons lost or referred to the stability of the potassium ions as being related to a 'full outer shell'.

(c) (i) Many candidates balanced the equation correctly. The commonest errors were to write 2H, H or H_2O in the second space on the right or to leave the first space blank.

(ii) Some candidates recognised that aqueous sodium hydroxide is alkaline and so has a pH which is above pH 7. A majority suggested a neutral or an acidic pH value.

Question 5

This was one of the least-well answered questions on the paper. Parts **(a)**, **(b)** and **(f)(ii)** were generally well answered. In **(c)**, few candidates described the colour change correctly. In **(d)(ii)**, few candidates realised that hydrogen could be produced by cracking alkanes. A minority of the candidates knew the combustion products of a hydrocarbon (**(e)**) or could state the meaning of the term polymer (**(f)(i)**). The descriptions of the pollution problems caused by plastic in **(f)(iii)** were often vague.

(a) Some candidates named the homologous series of alcohols and alkenes correctly. The commonest errors were to name specific compounds, e.g. 'ethanol', 'propanol' or 'propene' or to confuse alkenes with alkanes. A considerable minority suggested 'carboxylic acids' for the alcohol structure.

(b) The best answers drew the structure of ethanol showing all the atoms and all the bonds. The commonest errors in drawing the ethanol structure were the omission of a hydrogen atom, drawing the alcohol group as C–H–O or drawing an extra hydrogen atom on the oxygen atom of the O–H group. Others did not draw the bond in the O–H group. Many candidates drew the structures of alkanes or alkenes instead of ethanol.

(c) Few candidates knew the colour of aqueous bromine; 'blue', 'white' or 'reddish-brown' being the commonest incorrect answers. Those who realised that aqueous bromine is orange in colour often reversed the colour change. Many candidates did not realise that bromine is decolourised; many giving a definite colour such as 'yellow' or 'green' instead. A significant number of candidates wrote 'white' instead of colourless.

(d) (i) Most candidates gave one correct condition for cracking. Those who stated definite temperatures or pressures often got these wrong. The best answers involved 'catalyst and high temperature'. A significant number of candidates gave the name of incorrect catalysts, e.g. 'nickel' without mentioning the word catalyst.

(ii) Few candidates realised that hydrogen could be produced by cracking alkanes. The commonest incorrect answers were 'petroleum' or 'bitumen'.

(e) A minority of the candidates realised that the products of complete combustion of a hydrocarbon are carbon dioxide and water. The commonest errors were hydrogen instead of water or non-existent oxidation products such as 'propane oxide'. Others gave products containing elements, which did not appear in the reactants, e.g. 'sodium hydroxide'.

(f) (i) The best answers usually contained the idea of monomers as the small units which make up polymers and that polymers are long or large molecules. Most candidates gave vague answers when describing a polymer, often confusing the polymer with the monomer, e.g. 'small macromolecule'.

(ii) Most of the candidates described a suitable use for nylon. A few gave answers which were too vague, e.g. 'plastics'.

(iii) Some candidates described suitable problems with plastics in the environment such as 'they get stuck in the throats of animals and prevent them breathing properly'. Others wrote statements which were too vague such as 'land pollution' or 'give off gases'. A considerable minority misread the stem of the question and described the meaning of non-biodegradable instead of a pollution problem caused by plastics.

Question 6

In **(a)**, some candidates described the physical properties of potassium iodide and bromine correctly. Others gave answers which were too vague or bore no relation to the properties requested. A minority of the candidates identified the substance produced at the positive electrode in **(b)(i)**, or gave a suitable explanation for the lack of reactivity between potassium chloride and bromine in **(b)(iii)**. The change of state in **(c)** was well known.

(a) Some candidates described the physical properties of potassium iodide and bromine correctly. Others either gave answers which were too vague or bore no relation to the properties requested. The term volatility was not very well understood and many candidates thought that volatile compounds have high boiling points. Many candidates realised that potassium iodide is soluble in water. Fewer realised that bromine is (slightly) soluble even though the test for unsaturated compounds involves aqueous bromine. Many candidates suggested that both molten potassium iodide and bromine conduct electricity. A considerable number of candidates did not understand the question and wrote about solids, liquids and gases or their properties. Others wrote vague comparative answers referring to 'more soluble' or 'less volatile'.

(b) (i) A minority of the candidates suggested iodine. Some misread the question and chose chlorine. The commonest error was to suggest 'hydrogen', which would only be produced at the cathode (rather than the anode) and then only if the salt was in aqueous solution. Few candidates suggested potassium. Many more suggested incorrect answers such as 'carbon dioxide' or 'oxygen'.

(ii) The better performing candidates were able to name the products of the reaction between potassium iodide and bromine. The commonest error was to give incorrect suffixes: iodide instead of iodine and potassium bromine instead of potassium bromide. Other candidates suggested bromine iodide as a product, often accompanied by hydrogen.

(iii) Very few candidates wrote about the greater reactivity of chlorine compared with bromine. Most candidates either compared the reactivity of the halogen with the halides or compared it with potassium or with potassium compounds. Another common error was to compare the position of the halogens in the group without mentioning relative reactivity. Others wrote vague statements relating to electron shells and stability. A considerable number of candidates did not respond to this question.

(c) Most candidates were able to name the change of state when liquid bromine changes to solid bromine. The commonest incorrect answers were 'melting' and 'condensing'.

Question 7

This was one of the least-well answered questions on the paper. In **(a)**, many candidates confused the arrangement of the particles with the separation of the particles. In **(b)**, only a small number of candidates knew the major use of sulfur in industry. In **(c)(ii)**, a wide variety of incorrect oxides was seen. Parts **(c)(iii)** and **(d)** were generally well answered.

(a) Many candidates confused the arrangement of the particles with the separation of the particles. Others wrote about the motion of particles when answering the question about the separation of particles. Many candidates did not gain credit because their answers were too vague. Examples included: 'the arrangement of solid sulfur is more than in sulfur gas' and 'the separation is slightly more apart in sulfur gas than in sulfur solid'. Others wrote about the bulk properties of solids and gases rather than writing about particles. A considerable number of candidates ignored the word particles and wrote about methods of separating mixtures, e.g. 'use distillation'.

(b) Very few candidates realised that the manufacture of sulfuric acid is the major use of sulfur in industry. A considerable number of candidates gave a use of sulfur but this was rarely an industrial one. A common error was to suggest ‘food preservation’. A minority of the candidates did not obtain credit because their answer was not precise enough, e.g. ‘to make sulfur dioxide’ or ‘in making acids’. A considerable number of candidates did not respond to this question.

(c) (i) Some candidates knew an adverse effect of sulfur dioxide on health. Others wrote vague statements such as ‘it harms you’, ‘it causes disease’ or ‘it causes cancer’.

(ii) Some candidates ignored the stem of the question and suggested ‘sulfur dioxide’. The commonest incorrect answers were ‘carbon dioxide’ or ‘carbon monoxide’. A wide variety of other incorrect answers were seen, many of which were solid oxides, e.g. ‘copper oxide’.

(iii) Most of the candidates knew the symbol for a reversible reaction. The commonest errors were to draw a single line with an arrowhead at either end or to draw both half-arrow heads on the left.

(d) The best answers referred to the zinc gaining oxygen. Candidates who tried to answer the question in terms of electrons generally did do so correctly. A considerable minority of the candidates wrote about the sodium sulfite rather than the zinc or just referred to the equations, e.g. ‘there is zinc on the left and zinc oxide on the right’.

Question 8

This was one of the better answered questions on the paper, with many candidates performing well in **(c)**, **(d)** and **(e)**. In **(a)**, many candidates did not read the grid correctly. In **(b)**, many candidates drew the line for the final mass lower than 198.2 g.

(a) Many candidates did not read the values on the grid correctly and gave the value 38 s rather than 36 s.

(b) Many candidates drew the line for the final mass lower than 198.2 g. Others drew a shallower initial gradient or drew a steeper gradient which hit the original line on the curve at 40–60 s rather than levelling off before about 80 s. A few candidates did not gain credit for the initial gradient because their line followed the original line for more than five small squares. A considerable number of candidates did not respond to this question.

(c) Most of the candidates deduced the changes in rates correctly. The commonest errors were to comment on time taken for the reaction to finish, rather than rate; to refer to a rate increase when large pieces of calcium carbonate were used; or to explain the change in rate without mentioning what happens to the rate.

(d) Most candidates used simple proportion to answer this question correctly. The commonest error was a factor of 10 difference, usually 1.1 g instead of 0.11 g.

(e) Nearly all the candidates deduced the correct order of reactivity. The commonest errors were to suggest that nickel is more reactive than iron or to reverse the order completely.

CHEMISTRY

Paper 0620/33
Theory (Core)

Key messages

- Some candidates would benefit by improving their knowledge of specific chemical terms and processes.
- Many candidates need more practice in analysing the stem of a question.
- Some candidates need more practice in memorising chemical tests for specific ions.
- Interpretation of data from tables and completion of chemical equations was generally well done.

General comments

Many candidates tackled this paper well, showing a good knowledge of core Chemistry. The standard of English was generally good. Few of the questions were left unanswered.

Some candidates need more practice in writing answers with the correct amount of detail using or explaining specific chemical terms. For example, in **Question 1(c)** some candidates did not give a reason for the acidic nature of carbon dioxide whilst in **Question 3(a)** many wrote answers which were too vague such as 'for burning'. In **Question 3(b)(iii)**, many candidates wrote answers which did not refer to the equation. In **Question 3(d)(iv)**, attempts to describe the physical properties were sometimes hampered by vague statements. In **Question 4(d)**, (determination of pH) many candidates need to write their answers with more precision, mentioning the indicator colour chart. In **Question 5(c)(ii)**, the effect of carbon monoxide on health was often poorly described. In **Question 7(a)(ii)**, some candidates confused the separation and arrangement of particles with the movement of particles or wrote about bulk properties rather than particle properties. In **Question 7(d)**, (recycling aluminium) many candidates wrote vague statements such as 'lower impact on the atmosphere'. Many candidates need more practice in writing definitions. For example, in **Question 3(c)** many candidates had difficulty in explaining the term decomposition and in **Question 3(d)(i)** some candidates did not describe the term alloy accurately enough. In **Question 5(d)(i)**, many candidates wrote vague statements about cracking or suggested 'breaking elements'. In several places in the paper some candidates wrote about elements and compounds indiscriminately and this prevented credit from being awarded. For example, in **Question 3(c)**, when describing thermal decomposition, some candidates wrote about breakdown of elements rather than breakdown of compounds. Other candidates need to revise chemical nomenclature. The suffix ending of binary salts, -ide, was written as -ine by some candidates.

Some candidates need more practice in analysing the stem of a question to pick out the essential words needed to answer the question. In **Question 1(a)(v)**, some candidates did not distinguish between elements and compounds. In **2(a)(i)**, some candidates chose the negative ion with the lowest concentration rather than the positive ion. In **2(a)(ii)**, some candidates did not relate the name of the nitrate ion to the formula in the table. In **3(d)(iv)**, some candidates gave chemical properties rather than physical properties or did not heed the word 'other' in the stem of the question and gave 'malleable' or 'conducts electricity' as an answer. A similar omission occurred in **Question 4(d)**, where many candidates repeated the 'pH meter' in the stem of the question. In **Question 7(a)(ii)**, some candidates did not use the kinetic particle theory as requested.

Some candidates would benefit from further revision of specific topic areas such organic chemistry (**Question 5**), physical properties (**Question 3(d)(iv)**) and particle theory (**Question 7(a)(ii)**).

Many candidates need to revise qualitative tests for specific ions and molecules. The answers to the questions about the test for iron(III) ions (**Question 2(b)**)and the test for zinc ions (**Question 8(e)**) were not well known.

Many candidates were able to extract information from tables and graphs, balance symbol equations and undertake simple chemical calculations.

Comments on specific questions

Question 1

Some candidates identified three of the formulae correctly in **(a)**. Others seemed to guess the answers, as a wide range of incorrect answers were seen. In **(b)**, many candidates were able to complete the dot-and-cross diagram for water correctly. In **(c)**, few candidates gave a suitable reason why carbon dioxide is a basic oxide.

(a) (i) Some candidates realised that lithium ions produce a red colour in the flame test. The commonest incorrect answer was magnesium chloride. A wide variety of other incorrect answers were seen, some candidates choosing elements rather than compounds.

(ii) Some candidates identified $MgCl_2$ as having ions with a 2+ charge. The commonest errors were to suggest molecular structures such as HCl or SO_2.

(iii) Most of the candidates recognised CO_2 as a product of respiration. The commonest incorrect answer was O_2.

(iv) Some candidates recognised that SO_2 is a food preservative. A wide variety of incorrect answers were seen.

(v) A minority of the candidates recognised that O_2 is used in the production of steel. Many of the candidates chose compounds such as CH_4, SO_2 or KBr, which suggests that many guessed the answers.

(b) Common errors were to miss out the non-bonding electrons on the chlorine, to give three pairs of non-bonding electrons rather than two and/or to add a non-bonding electron to the hydrogen atom. A few candidates drew either one or three pairs of bonding electrons.

(c) This was the least-well answered part of **Question 1**. Many candidates thought that carbon dioxide oxide was a basic oxide; some stated that 'carbon is a metal'. The reason was often not specific enough. Many answers either referred to calcium oxide being an acidic compound or tried to relate acidity to chemical reactivity.

Question 2

This was one of the best-answered questions on the paper. Many candidates gave good answers to **(a)(i)**, **(a)(iii)** and **(c)(ii)**. In **(a)(ii)**, many wrote the name of the nitrate ion incorrectly. Very few candidates knew the test for iron(III) ions in **(b)** and in **(c)(i)**, many candidates did not recognise the alcohol functional group.

(a) (i) Most candidates selected the Fe^{3+} ion as having the lowest concentration. The commonest error was to suggest 'nitrate' through not reading the stem of the question carefully enough and selecting a negative rather than a positive ion. Another common error was to select the ammonium ion.

(ii) Some candidates gave the correct name. Others did not use the information in the table and gave the name of made-up nitrogen compounds such as 'calcium nitrogen oxygen' or 'calcium nitroxide'.

(iii) Most candidates did the calculation correctly using simple proportion.

(b) Very few candidates knew the test for iron(III) ions. Flame tests were occasionally suggested or reaction with silver nitrate or with hydrochloric or nitric acids. Some candidates realised that a red-brown precipitate would be formed but the test reagent was invariably incorrect. White or green precipitates were often suggested. A few candidates suggested tests which were more appropriate for gases. A considerable proportion of the candidates did not respond to this question.

(c) (i) Most candidates put a circle around the OH of a COOH group or all around a COOH group. Many candidates did not appear to know the meaning of a functional group because they included large portions of the carbon chain within their ring. A few candidates put a ring around the –NH group.

(ii) Many candidates deduced the molecular formula of compound **A** correctly. The commonest errors were to omit the N of the NH_2 group or to miscount the number of hydrogen atoms as six or the oxygen atoms as two.

(iii) The majority of candidates calculated the relative molecular mass correctly. The commonest errors related to misreading the formula of the compound, seven hydrogen or three oxygen atoms being used in the calculation. Others misread the question and calculated the relative molecular mass of compound **A**.

Question 3

Many candidates were able to balance the equation in **(b)(ii)**, identify the alloy in **(d)(ii)** and deduce the number of subatomic particles in **(d)(iii)**. Others gave vague answers when describing the purpose of the air blast used in the production of iron. In **(a)**, many gave reasons which were far too vague. A minority of the candidates referred to the equation in **(b)(iii)** and most could not give a full definition of thermal decomposition in **(c)**. In **(d)(iii)**, many candidates did not read the stem of the question properly and suggested ‘malleable’ or ‘conductor of electricity’, which were mentioned in the stem.

(a) Few candidates gave two correct answers for blowing air through the blast furnace. Most gave vague answers or incorrect answers such as ‘to help extract the iron’ or ‘to help reduce the iron oxide to iron’.

(b) (i) Some candidates gave a spelling of hematite which was sufficiently phonetic to be given credit. Others gave spellings such as ‘hamide’ or ‘haemate’, which were too far from the correct spelling. Another common error was to suggest ‘iron ore’ despite ‘ore of iron’ being in the stem of the question. Others gave names of compounds such as ‘iron oxide’. A considerable number of candidates did not respond to this question.

(ii) Most of the candidates were able to balance the equation correctly. The commonest errors were to write 2Fe or $2CO_2$.

(iii) The best answers stated that ‘oxygen is removed from iron oxide’. The majority of the candidates gave answers which were too vague and did not refer to the equation, e.g. ‘oxygen is removed’. Some candidates referred to the iron (which is on the right-hand side of the equation) rather than the iron oxide (which is on the left). Others just wrote about carbon monoxide gaining oxygen rather than the iron oxide losing oxygen.

(c) Many candidates defined the term thermal correctly. Others gave vague answers referring to heat loss or contradictory answers referring to loss and gain of heat. Fewer candidates gave a suitable description for the term decomposition, with many spoiling their answers by suggesting ‘breakdown of elements’ or the vague ‘breakdown of particles’.

(d) (i) Some candidates gave a suitable definition of an alloy. Others spoiled their answers by referring to ‘compounds of different metals’ or wrote conflicting statements such as ‘mixtures of metals or mixtures of non-metals’.

(ii) Many candidates recognised the alloy as structure **E**. The commonest incorrect structures were **B** or **D**.

(iii) Most of the candidates deduced the number of electrons, neutrons and protons correctly. The commonest errors related to the number of neutrons; the number of neutrons often being given as 51 (the mass number) or 74 (addition of mass number to proton number). The number of electrons was occasionally given as 21 or 22 through confusion with ions rather than atoms.

(iv) The best answers focussed on ductility and conduction of heat or lustre. Many candidates did not read the stem of the question properly and suggested 'good conductor of electricity' or 'malleable', which were mentioned in the stem. Others suggested chemical properties instead of physical properties. Others gave properties which are not characteristic of all metals, e.g. high density.

Question 4

Parts **(a)** and **(c)** were generally well answered. Few candidates gave a suitable reason for a bromide ion having a single negative charge in **(b)(ii)**. In **(d)**, a minority of the candidates gave suitably precise answers to gain credit for describing how to find the pH of an acidic solution using universal indicator.

(a) (i) Most candidates deduced the boiling point and density correctly. The commonest error was to suggest a boiling point of iodine which was below the melting point of iodine.

(ii) Most candidates described the trend in the melting points of the halogens correctly. The commonest errors were either to state that 'the halogens at the top are low and the bottom are high' or to reverse the trend. A number of candidates tried to link the melting point to the density.

(b) (i) Some candidates gave the correct electronic structure of chlorine as 2,8,7 or described this in words or as a diagram. Others gave 2,8,5 or just stated that 'there are 7 electrons in the outer shell'. A considerable minority wrote 17; the total number of electrons. A significant number of candidates did not respond to this question.

(ii) The best answers referred to the bromide ion having one more electron than protons. Most candidates did not gain credit because they either wrote about the reactivity of bromine or referred to bromide ions, rather than bromine atoms gaining one electron. Others did not gain credit because they either did not specify the number of electrons gained or referred to the stability of the bromide ions as being related to a 'full outer shell'.

(c) Many candidates gained credit for the word equation. The commonest errors were to write sodium chlorine (rather than sodium chloride), astatide (instead of astatine) or to give hydrogen or water as one of the products.

(d) Many candidates did not refer to universal indicator and suggested litmus or methyl orange in its place. Others repeated the stem of the question by suggesting 'measure the pH'. Some candidates referred to dipping universal indicator paper into the acid. Most of the candidates who mentioned universal indicator just referred to 'using the universal indicator to find the pH'. The best answers included the idea of matching the colour of the indicator paper to the colours on a universal indicator colour chart.

Question 5

This was the least-well answered question on the paper. The organic chemistry in **(a)**, **(b)** and **(c)** was well answered by a minority of the candidates. Many others did not recognise the organic structures. In **(d)(ii)**, most candidates wrote vague statements when defining the term cracking. A minority of the candidates knew the product of the reaction between ethene and steam in **(d)(ii)** and many were able to recognise the term polymer in **(d)(iii)**. The products of the complete combustion of a hydrocarbon in **(e)** were not well known.

(a) Some candidates named the homologous series of alkenes and alkanes correctly. The commonest errors were to name specific compounds, e.g. 'ethene' or 'propane' or to confuse alkenes with alkanes. A considerable minority suggested 'alcohols' for the ethene structure.

(b) The best answers drew the structure of ethanoic acid showing all the atoms and all the bonds. The commonest errors in drawing the structure were drawing the –COOH group with only one double-bonded oxygen atom or having too many bonds around the C=O carbon atom.

Some candidates drew structures of alcohols or carboxylic acid-type structures with three carbon atoms. Others did not draw the –O–H bond in the –COOH group. Some candidates drew the structures of alkanes or alkenes instead of ethanoic acid. A significant number of candidates did not respond to this question.

(c) Some candidates recognised the structure formed by the addition of bromine with ethene. The commonest errors were to suggest **Q** or **R**, both of which contain double bonds.

(d) (i) The best answers about the term cracking included the idea of breakdown of long(er) chain alkanes or hydrocarbons to shorter chains at a high temperature. Many correctly referred to using 'heat' or 'high temperature'. Others did not mention alkanes or hydrocarbons and wrote about 'breaking compounds' or 'breaking down elements'. A significant minority of the candidates did not recognise cracking in terms of chemistry and wrote answers about 'cracking rocks' or 'cracked plates'.

(ii) A minority of the candidates knew the product of the reaction between ethene and steam. Many appeared to guess and wrote answers such as 'polymers' or 'ethene oxide'. Others wrote the non-specific answer 'alcohols'. A significant number of candidates did not respond to this question.

(iii) Most candidates recognise the term polymer. The commonest incorrect answer was 'monomer'.

(e) A minority of the candidates realised that the products of complete combustion of a hydrocarbon are carbon dioxide and water. The commonest errors were hydrogen instead of water or made-up oxidation products such as 'propane oxide'. Others gave products containing elements which did not appear in the reactants, e.g. 'sulfur dioxide'.

Question 6

In **(a)**, some candidates described the physical properties of potassium iodide and bromine correctly. Others either gave answers which were too vague or bore no relation to the properties requested. A minority of the candidates identified the substance produced at the positive electrode in **(b)**. Many candidates did not recognise incomplete combustion in **(c)(i)**. A greater number of candidates gave a correct effect of carbon monoxide on health in **(c)(ii)**.

(a) Some candidates described the physical properties of sodium chloride and pentane correctly. Others either gave answers which were too vague or bore no relation to the properties requested. The term volatility was not very well understood and many candidates thought that volatile compounds have high boiling points. Some candidates realised that sodium chloride is soluble in water. Others did not recognise the structure as an ionic compound and suggested 'does not dissolve'. Many candidates suggested that neither molten sodium chloride nor molten pentane conduct electricity. A considerable number of candidates did not understand the question and wrote about solids, liquids and gases or their properties. Others wrote vague comparative answers referring to 'more soluble' or 'less volatile'.

(b) A minority of the candidates suggested chlorine. The commonest error was to suggest 'oxygen', which would only be produced if the solution was dilute. Others suggested 'hydrogen' which would only be produced at the cathode (rather than the anode). Few candidates suggested potassium. Many more suggested 'carbon dioxide', thinking that the carbon electrodes were oxidising.

(c) (i) The best answers referred to 'incomplete combustion' or 'combustion in less oxygen than complete combustion'. Some candidates suggested 'combustion when no oxygen is present'. A considerable number of candidates wrote vague statements about temperature and pressure. A significant number of candidates did not respond to this question.

(ii) Better answers referred to the toxic or poisonous effects of carbon monoxide. Many answers were too vague or incorrect, e.g. 'it is harmful' or 'it causes cancer'. Others gave answers relating to the mechanism of action of carbon monoxide rather than specifying an overall effect on health.

Question 7

Part **(a)(i)** was generally well answered. In **(a)(ii)**, many candidates confused the separation of the particles with the arrangement of the particles. In **(b)**, some candidates answered the question in terms of relative reactivities. Most wrote about general chemical properties. Many gave at least one suitable reason for the use of aluminium in aircraft manufacture in **(c)** and deduced the order of reactivity correctly in **(e)**. Fewer candidates gave a suitable advantage of recycling aluminium in **(d)** or gave a suitable source and adverse effect of methane in **(f)**.

(a) (i) Nearly all the candidates named the change of state from solid to liquid correctly. A few candidates suggested sublimation.

(ii) Some candidates confused the separation of the particles with their arrangement. The difference between the solid and liquid in terms of motion of the particles was better described. Some answers were too vague. Examples included: 'the separation of solid aluminium is more than in aluminium liquid' and 'the separation in aluminium is separated'. A few candidates ignored the word particles and wrote about methods of separating mixtures, e.g. 'use distillation'. Others wrote about the bulk properties of solids and liquids rather than about particles.

(b) The best answers described aluminium as being 'more reactive than carbon' or that 'aluminium is too reactive to be extracted by heating with carbon'. Others wrote vague statements such as 'aluminium is reactive' (which does not indicate its position in the reactivity series) or 'aluminium has a high melting point' (which is not necessarily related to reactivity).

(c) Many candidates gave at least one suitable reason for the use of aluminium in aircraft manufacture. The commonest correct answer referred to low density. Common errors included 'good electrical conductor' or 'has a low melting and boiling point'.

(d) The best answers referred to saving energy or conserving natural resources. Many candidates wrote vague responses, for example 'good for the environment' or 'lower impact on the atmosphere'.

(e) Nearly all the candidates deduced the correct order of reactivity. The commonest errors were to suggest that zinc is more reactive than titanium or to reverse the order completely.

(f) (i) Many candidates gave a source of methane such as 'from swamps', or 'from decay of plants'. Few candidates, however, gave the main source of methane as natural gas. A significant number of candidates did not respond to this question.

(ii) A minority of the candidates suggested 'global warming' or gave an effect of global warming. The majority gave effects which were too vague to be given credit, e.g. 'air pollution' or 'harms the environment'.

Question 8

This was one of the better answered questions on the paper, with many candidates performing well in **(a)**, **(c)** and **(d)**. In **(e)**, many candidates did not know the test for zinc ions.

(a) Most candidates read the grid correctly. The commonest error was to suggest 34 s.

(b) Most candidates drew a steeper initial gradient. Others drew the line for the final mass higher or lower than 35 cm^3. A few candidates either drew a shallower initial gradient or drew a steeper gradient which hit the original line on the curve before about 60 s. A small number of candidates did not gain credit for the initial gradient because their line followed the original line for more than five small squares.

(c) Most of the candidates deduced the changes in rates correctly. The commonest errors were to comment on time taken for the reaction to finish, rather than rate; to refer to a rate decrease when zinc powder is used, or to explain the change in rate without mentioning what happens to the rate.

(d) Most candidates used simple proportion to answer this question correctly. The commonest error was to multiply 0.065 by 24 ÷ 96.

(e) Some candidates knew the test for zinc ions using aqueous ammonia. A variety of different coloured precipitates was suggested on addition of a few drops of aqueous ammonia, including ‘brown’, ‘green’ or ‘orange’. Others omitted the word precipitate. Those who chose the correct answer ‘white precipitate’ usually incorrectly suggested that the white precipitate remains when excess aqueous ammonia was added. A significant number of candidates did not respond to this question.

CHEMISTRY

Paper 0620/41
Theory (Extended)

Key messages

- Ionic equations, including half-equations, continue to be an area that needs considerable improvement.

- Candidates are advised that if a question asks for either observations or a description of what would be seen, the candidate should give (as appropriate):
  - colour changes (requiring initial and final colours)
  - effervescence
  - solids dissolving or disappearing
  - colours of gases
  - colours and state of products of electrolysis.

- It is apparent that many candidates were not as prepared for questions on Organic Chemistry as they were for questions on the rest of the syllabus. This was evident mainly in answers to **Questions 5(a)–(d)**.

- Recall of definitions is an area that needs to be developed.

Comments on specific questions

Question 1

(a) (i) This question was answered well with the majority of candidates choosing hydrogen as the only non-metal in the list.

(ii) Few candidates answered this well with a common error being to choose calcium or magnesium being stored in oil.

(iii) This question was answered well with the majority of candidates recognising that iron was the main component of steel, with the most common error being zinc.

(iv) This question was answered very well with the majority of candidates knowing that aluminium had three electrons in its outer shell; the most common error being magnesium.

(v) This question was answered very well with the majority of candidates knowing that either copper or zinc was the main component of brass.

(vi) This question was answered less well with many candidates not recalling that transition metals have variable oxidation states, with the most common error being sodium.

(b) (i) Few candidates could recall that the main ore of zinc was zinc blende. Answers such as zinc oxide, zinc sulfide and zinc carbonate were commonly seen. Many candidates did not attempt this question.

(ii) Candidates were able to recall that the main ore of aluminium was bauxite; there was some confusion with haematite or offering alumina as an answer.

(c) Candidates found this question challenging with the majority not being able to describe that aluminium has a protective oxide coating hence making it less reactive. Most candidates referred to impurities in aluminium making it less reactive or the fact that it needed to lose three electrons to react. A small number of candidates had the idea that the aluminium reacted with the oxygen in the air but did not develop the idea further that the aluminium oxide coating was protective or inert.

(d) This question was answered very well with the majority of candidates knowing that the less reactive elements such as iron, carbon and zinc could be extracted from their ores with carbon.

(e) (i) Candidates found this question difficult and, while they had both the products of the reaction correct, many gave 'zinc sulfate'. Candidates are encouraged to think carefully about the 'states' of the substances.

(ii) Candidates found this question difficult and, while they had both the products of the reaction correct, they put the answer 'copper'. Candidates are encouraged to think carefully about the 'states' of the substances, e.g. is copper metal going to be a solution?

(iii) The majority of answers used the idea of particles colliding faster or the particles having more energy. It was less common to see explanations that stated there were a greater frequency of collisions rather than there just being more collisions. Very few responses noted that a greater proportion of collisions were successful or that more of the particles had energy greater than or equal to the activation energy. Just stating there are more successful collisions is insufficient as if there are more frequent collisions there must be more successful collisions.

(iv) Many candidates were able to offer a suitable alternative to temperature as ways of increasing the rate of a reaction and this included use of a catalyst, increasing the concentration of copper(II) sulfate and increasing the surface area of zinc granules. Some candidates wrote 'concentration', which is insufficient to gain credit as concentration can either increase or decrease. Common misconceptions were to increase the pressure, use more zinc and to reduce the space of the reaction vessel.

Question 2

(a) (i) The majority of candidates were able to recall the term isotope for atoms of the same element with different nucleon numbers.

(ii) Most candidates were able to calculate the numbers of protons, neutrons and electrons in the copper atom and ion. There were no common errors but the responses for the atom were marginally more accurate than those for the ion.

(iii) Candidates found this question about the link between isotope ratios and relative atomic mass difficult. This suggests that, in many cases, candidates did not understand how the relative atomic mass is determined from the average mass of all isotopes in an atom. Many candidates found the average of both atoms without considering the weighted average giving an answer of 64.0. Candidates should also be mindful of the number of decimal places required for a response.

(b) (i) Many candidates were unable to recall the colour change for the presence of water as colourless to blue with the most common error being white. It was apparent that some candidates do not understand the difference between colourless and white.

(iii) Many candidates did not include enough detail in their response and did not refer to the command word of 'how' the process could be reversed. The most common answer was 'evaporate/remove the water' but candidates did not say 'how' they would carry out this process such as heating or using concentrated sulfuric acid. Some candidates wanted to 'boil' the hydrated copper(II) sulfate but candidates should be mindful that this is a solid so cannot be boiled.

(iv) Some candidates were able to identify that the test for water is to see if the boiling point was 100°C. Most commonly, candidates wanted to filter the water, test the pH or evaporate the water to see if there were any solids left.

(c) (i) Many candidates were able to recall that a blue precipitate was formed, with the most common error being a white precipitate was formed.

(ii) Candidates found this challenging. Many attempted a symbol equation instead of an ionic equation but could identify that copper(II) hydroxide was produced in the reaction. In an ionic equation for a precipitation reaction, the two ions in aqueous solution that react to form the precipitate are on the left hand side and **aqueous**. The **solid** precipitate is on the right hand side. This was known to only a small number of candidates.

(d) This was done well by about half of all candidates who could calculate the volume of nitrogen was 1.2 dm^3. Common errors were to incorrectly calculate the mass of one mole of copper(II) nitrate and then use this value in the calculation. Another common error was to use the mole ratio given in the equation of 2:4 rather than calculating the actual number of moles present leading to an answer of 96 dm^3.

(e) The majority of candidates found this very difficult. Most could not recall that sodium nitrite is made in the decomposition of sodium nitrate and those that did could not write a correct formula for sodium nitrite. A lot of candidates did not attempt this question.

Question 3

(a) (i) Candidates found the ionic equation challenging. Many could not recall the formula for chlorine is Cl_2, and many candidates tried to balance the equation using symbols such as H or HCl rather than balancing the number of atoms.

(ii) More than half of candidates knew that the process described was oxidation but then incorrectly identified the species being oxidised. Many thought that the chlorine not the chloride ions were oxidised.

(b) Many candidates were able to recall that effervescence was seen at the cathode but a handful of candidates gave a product of the reaction and not an observation. Candidates should be aware that if the question requires what is 'seen', an observation of what they would see is required and not just the products of the reaction.

(c) The ionic equation proved difficult for many candidates. The hydrogen species on the left was often uncharged or had the wrong charge.

(d) (i) Many candidates knew that the solution was acidic but the question required a numerical value from the pH scale, so a number in the range 1-3 should have been stated.

(ii) Many candidates had appreciated that the solution became less acidic, but most candidates did not give a quantitative response; since the pH scale is a numerical scale this is required. Those candidates that did appreciate pH increased could not then go on to explain the reason for this was due to H^+ ions being removed from the solution. Candidates should not try to make vague statements such as 'the pH changes' but be more specific as to how it changes. Only a small minority of candidates gained full credit for this question.

(e) Many of the answers ignored the instruction to give observations. The candidates could identify the correct products but did not state what would be observed.

The following non-creditworthy statements were commonly seen:

- bromine forms
- silver metal
- lead forms
- bromine gas
- solid lead
- bromine bubbles.

(f) This question was done well by the majority of candidates who could recall that graphite was inert and a good conductor of electricity. A handful of candidates were not specific enough and said it was just a 'good conductor' and some thought that graphite was a metal.

Question 4

(a) This was a demanding question and most candidates could not identify the formulae for the products of the reaction. Those that could do this produced a perfectly balanced equation.

(b) (i) This question was poorly answered and candidates were clearly unfamiliar with features of an equilibrium. 'The forward reaction equals the backward reaction' is not the same as 'the rate of the forward reaction is equal to the rate of the backward reaction', and 'the concentration of the reactants and products are the same or equal' is not the same as 'the concentration of the reactants and products is constant'. Other common errors were saying the reaction is reversible, can be reversed and happens at a constant rate.

(ii) The command word 'state' means give a numerical value for a temperature or pressure and a handful of candidates wrote high or low. The majority of candidates could recall the temperature and pressure for the Contact process with temperature being answered marginally better. There was confusion with quoting the temperature or pressure for the hydration of ethene or the Haber Process.

(iii) Few candidates could recall the correct catalyst for the process with many thinking iron was the catalyst for this process. Some did not gain credit as they missed the oxidation state or put the incorrect oxidation state in vanadium(V) oxide. A handful of candidates thought that oxygen was the catalyst for this process.

(iii) This question was answered well with the majority of candidates being able to recall that a catalyst increases the rate of a chemical reaction. A small number of candidates thought that a catalyst increased the yield as well as the rate.

(v) This question was poorly answered and indicates that candidates are not confident with equilibrium.

A good response stated:

- the forward reaction is exothermic
- therefore, the equilibrium shifts to the left-hand side when the temperature is increased.

There were many references to the equilibrium breaking and that the reaction would go backwards. As equilibrium reactions are reversible, candidates need to say that the equilibrium moves/shifts backwards rather than 'goes backwards'.

The equilibrium shifts to the endothermic side is not sufficient as the candidates must state which direction the reaction is shifting.

(c) This was done very well.

Question 5

(a) More candidates should have been able to recall the name of a family of compounds as a 'homologous series'. Common errors were simply to say 'group' or to give an example of a homologous series.

(b) The majority of candidates were able to correctly state the general formula of an alkene. A few candidates confused the formula with that of an alkane and a handful of candidates incorrectly stated $C_n + H_{2n}$.

(c) (i) Some candidates confused the colour change as being colourless to orange.

(ii) Only a few candidates could give the correct definition of an addition reaction as being one that only produces one product. Many simply repeated the question with phrases such as when one substance is added to another. Candidates should be mindful not to repeat words used in the stem of the question as this will not be creditworthy. Other candidates tried to make the term too specific by referring to polymerisation.

(iii) Some candidates could write the equation for the reaction between but-2-ene and bromine, where the most common error was not using bromine as a diatomic molecule.

(iv) Many of the candidates were able to suggest the name of the polymer but a few named polymers that they knew from other sections of the syllabus such as nylon or *Terylene*.

(v) Some candidates were able to identify but-1-ene as the isomer of but-2-ene but then included pentavalent carbons in their structure. A few just simply drew out but-2-ene as a linear structure or drew but-2-ene as a bent structure with one alkyl group at right angles to the main structure. Most candidates that attempted the question showed all the atoms and all the bonds.

(d) (i) The most common error by candidates in this question was to write the molecular formula as opposed to the empirical formula.

(ii) A very small minority could identify the sodium salt formed and a few could recognise that carbon dioxide and water were produced.

(iii) Some candidates were able to correctly name the ester. Those candidates who could name the ester generally could draw a correct structure showing all the atoms and all the bonds. Some candidates showed a correct ester linkage attached to the incorrect number of carbons. Pentavalent carbons were common, as were divalent hydrogens and structures of carboxylic acids.

CHEMISTRY

Paper 0620/42
Theory (Extended)

Key messages

- If the symbol or formula of a chemical is asked for, a name will not gain credit. This was the case in **Question 6(c)(i)** where the formula of the substance (ethene) was asked for. Candidates who wrote 'ethene' received no credit.
- Where names of organic compounds are asked for, candidates should not give a formula as a correct name shows understanding of the prefix and of the suffix of organic nomenclature.
- Where responses require one answer, e.g. **Question 1(d)**, where one process and one type of reaction were asked for, then candidates should only give one response as additional incorrect responses could potentially negate a previous correct response.

General comments

Candidates appeared to have sufficient time for all questions to be answered.

Many candidates found **Question 6**, involving organic chemistry, challenging.

Candidates seemed well prepared for mole calculation questions.

Comments on specific questions

Question 1

(a) Most candidates were able to describe the properties of a gas and a solid. The properties of a liquid caused problems, with many candidates only selecting either the touching or the random movement of particles.

(b) (i) Most candidates appreciated that boiling occurs at a specific temperature and many went on to state that evaporation was a surface phenomenon.

Weaker responses often used both answer lines to state the same point, e.g.:
1 boiling occurs throughout a liquid
2 evaporation happens at the surface of a liquid.

(ii) Both processes were well known by most of the candidates.

(c) A good proportion of candidates could draw the cooling curve correctly, although there were a significant number who drew the horizontal line level with **B** rather than Y. Better responses ensured the horizontal line was level with Y by drawing a horizontal construction line.

(d) (i) Most candidates recognised the description of dissolving, but weaker responses stated 'mixing' or 'diffusing'.

(ii) Precipitation (often misspelt as 'percipitation') was slightly less well known and 'neutralisation' or 'crystallisation' were common errors.

Question 2

(a) (i) Most candidates were able to describe these acids as 'strong'; some rephrased the information given and answers such as 'completely ionised' or 'dilute' were seen.

(ii) The equation caused considerable problems with only small numbers of candidates appreciating the formation of H^+ ions. Many of those who realised that sulfate ions were formed did not balance the equation. A very common incorrect response was to show the formation of water and sulfur dioxide.

(iii) The colour of methyl orange in acid was generally well answered; sometimes there seemed to be confusion with phenolphthalein as 'colourless' was seen.

(b) (i) Errors such as 'Aq', 'AQ' or 'G' were seen very infrequently. From the information given, candidates were expected to appreciate that the reactants were '(s)' and '(aq)'. Many assumed the dilute acid was '(l)'. Candidates were expected to use their knowledge of reactions of acids and carbonates to appreciate that zinc nitrate was '(aq)'. Many erroneously opted for '(s)'.

Weaker responses did not include brackets around the state symbols.

(ii) Many candidates carried out the calculation perfectly; others started well but struggled with the concentration stage, often forgetting to convert using 1000.

Many candidates successfully calculated the mass of 1 mole of $ZnCO_3$ in their working, but then wrote a different value (usually 2.5 g as given in the question) on the answer line.

Question 3

(a) This simple recall question was poorly answered. Many responses only had '+' and '–' for the relative charge of a proton and electron. Many charges on masses were seen or the mass of a neutron was given as zero.

Candidates should be advised not to represent the absence of a charge on a neutron with a dash as, unfortunately, this reads as a minus sign.

(b) This question was excellently answered by many candidates, but candidates who performed less well struggled to achieve more than the straightforward part for sulfur. The identification of the bromide in the final task sometimes caused confusion, with Se often recorded and often the mass number was recorded as 80, not 79.

Question 4

(a) This question asked candidates to explain the exothermic nature of the reaction based upon energy changes of bond breaking and bond making.

Three simple statements would have sufficed:
- bond breaking takes in energy
- bond making releases energy
- the energy change of bond making is greater than bond breaking.

Very few candidates gave all three statements and poor phrasing was common.

A typical answer such as 'more energy is released in bond making than breaking' incorrectly suggests bond breaking also releases energy.

Similarly, 'less energy is required to break bonds than make bonds' suggests bond making requires energy.

Weaker responses ignored the idea of bond breaking / making and thought it was sufficient to write that the process was exothermic because 'energy is lost'.

(b) (i) Most candidates struggled with this question. Although many candidates appreciated that the product was at a lower energy level, sometimes the line drawn was not labelled with the product.

The idea of activation energy was poorly represented with few drawing the traditional 'hump'. Candidates should realise that energy increases are represented by upward, single-headed arrows.

The ΔH arrow had to be a single-headed arrow, going from the energy level of the reactants to the energy level of the products.

Better responses drew a horizontal construction line from the energy level of the reactants and ensured both the activation energy arrow and the ΔH arrow started from the correct point. Weaker responses frequently contained arrows which did not cover the full energy change they were meant to represent.

(ii) The role of the catalyst was well known, although some assumed it was the identity of the catalyst which was required.

(c) (i) (ii) Candidates were asked to describe the effect, if any, on the position of equilibrium when factors were changed. Thus, both answers needed a statement such as, 'the equilibrium moves to the right / left / or does not move'. Very few candidates expressed answers in such a succinct manner and many rambling, self-contradictory responses were seen.

One frequently seen response in **(i)** was that the equilibrium shifted to the side where there was lower pressure; this gained no credit as both sides have equal pressure.

One frequently seen response in **(ii)** was that the equilibrium shifted to the endothermic side; this gained no credit as reactions do not have endothermic / exothermic *sides*.

Candidates were required to explain their description in the change of equilibrium and in **(i)** most realised that increased pressure would shift the equilibrium towards the side with the fewer moles.

The explanation of equilibrium shift in **(ii)** needed the simple fact that the forward reaction was exothermic.

Weaker responses attempted to give explanations based upon changes to reaction rate or changes in collision rate.

(d) This was a challenging question. The energy change (1545 kJ / mol) when product bonds are made was often correctly calculated, but few candidates successfully progressed beyond this.

Most candidates did not appreciate that the 230 kJ / mol of energy released in the reaction must be used in the calculation.

(e) The dot-and-cross bonding diagram was generally well done. The most common error was to either omit or miscount the non-bonding electrons. One simple way of checking that all non-bonding electrons have been drawn is to draw these in pairs – it is easier to quickly count three pairs than six individual dots.

Some candidates opted to use a third type of electron symbol (e.g. a small triangle) to represent electrons from a third type of atom and this was accepted.

Question 5

(a) Although metallic bonding was recognised by many candidates, there were many who thought it was ionic or covalent bonding. Some candidates thought that the question related to bonding between iron and potassium and their subsequent descriptions gained little credit.

For those who did opt for metallic bonding, the description relied upon three key points:

- positive (or metal) ions (in a lattice)
- mobile (or delocalised) electrons
- *attraction* between the two oppositely charged particles.

Most candidates omitted the last point.

Candidates should be made aware that the term 'free electrons' does not mean 'mobile electrons'.

(b) (i) Most candidates recognised the description of 'malleability', although 'ductile' was a common error.

(ii) Most candidates appreciated that the key point to this response was that layers of particles (positive ions) can slide over one another.

(iii) Most candidates did not appreciate that a comparative answer was needed, so a statement such as 'copper is a good conductor' was insufficient. Good comparative responses included, 'copper is a better conductor (than other transition elements)'.

(c) A good proportion of candidates performed well, but some did not appreciate that the question asked about physical properties, so responses such as 'good catalysts' or 'variable oxidation number' received no credit. Also, physical properties common to all metals such as 'good conductor of electricity' were common responses.

(d) (i) This question was designed to tests candidates' knowledge and understanding of Group I elements. Most of the better performing candidates were able to recall the colours of the flames of Na and K and nearly all candidates spotted that a colourless solution would remain when rubidium reacted with water. Only a very few were able to describe the increased reactivity of rubidium with water. The best responses stated, 'more vigorous effervescence than potassium'.

(ii) (iii) These parts were well answered.

(iv) Most candidates gave a correct response in the form of a whole number for the pH of an alkaline solution. Some candidates opted for a range, but weaker responses often included 7 in their range.

(v) The equation was poorly written with a very only small proportion of candidates managing to correctly identify the formula for sodium oxide.

(e) (i) Most candidates knew that the Haber process produced ammonia, but weaker responses gave N as a reactant and NH_4 as a product.

(ii) The conditions for the Haber process were well known.

Question 6

(a) The general formula of alcohols was well known but candidates needed to take care over use of subscripts. Frequently C_nH_{2n}+1OH was seen, which did not receive credit.

(b) Most candidates were able to point out that ethanol does not contain only carbon and hydrogen due to the presence of an oxygen atom (other acceptable terms included hydroxyl group, OH group). However, it is incorrect to say that ethanol contains hydroxide ions or oxygen molecules.

(c) (i) The identity of the source of ethanol was well known, but many candidates misread the question and gave the name 'ethene' instead of its formula.

(ii) Glucose (or any sugar) was well known as the source of ethanol in fermentation.

(d) The equation for the combustion of ethanol was poorly answered. Many candidates did not seem familiar with the requirement for oxygen as a reactant in complete combustion. Various carbon-based products were often seen, for example methane, in combination with carbon dioxide and water.

(e) (i) Although most candidates showed a good understanding of empirical formula, frequently the molecular formula of **X** was given.

(ii) Many candidates included one ester link in their structure but only a small proportion of candidates achieved gave a fully correct structure for **X**.

(iii) This was answered correctly by most candidates.

(f) (i) Most candidates correctly named the functional group as carboxylic acid (carboxyl was also accepted), although a significant number gave –COOH as the answer and did not gain credit.

(ii) Very few candidates were able to determine the structure of **Y**. Some correct structures did not show the O–H bond.

CHEMISTRY

Paper 0620/43
Theory (Extended)

Key messages

- There were many excellent papers seen.
- Candidates consistently make mistakes in writing and balancing chemical equations. The main problem was a lack of knowledge of chemical formulae.
- Organic chemistry is an area of study where candidates consistently perform poorly. The responses to **Question 7** suggest that most candidates have a very poor understanding of organic reactions and polymers. Many candidates also had problems with formulae and structure of organic compounds.
- Candidates continue to find ionic equations extremely challenging.

General comments

Candidates have difficulties with questions that ask them to state the observations or to say what they would see when an experiment is performed. It is unnecessary to give names of substances in answer to such questions. Points that should be essential parts of the answers to such questions are:

- colours and changes in colour
- effervescence
- solids dissolving or disappearing
- precipitates forming.

Comments on specific questions

Question 1

(a) This was well known.

(b) Hematite was occasionally seen.

(c) Carbon dioxide and ammonia were occasionally seen.

(d) to **(h)** These parts were answered extremely well.

(i) This was answered less well. Oxygen was commonly seen.

Question 2

(a) This was answered reasonably well. Candidates occasionally stated the meaning of electrolysis rather than electrolyte. It is advisable for candidates to start their answer with, 'An electrolyte is a substance….'. The fact that electrolytes contain ions or are ionic substances was omitted on occasions, as was the fact that electrolytes are aqueous or molten.

(b) (i) Many responses did not include observations.

Copper was often described as black or blue. The description of copper as a metal as opposed to a solid was seen occasionally. The word precipitate was occasionally incorrectly used as a description of copper. Copper was sometimes incorrectly named as copper(II).

(ii) This straightforward question was poorly answered. H^- was occasionally seen rather than H^+, as was H rather than H_2. The equation was sometimes unbalanced.

(iii) The ability to conduct electricity is among the most important requisite of any material used as an electrode; this was often omitted. Those that referred to conductivity sometimes omitted the term electrical or electricity. Some candidates suggested that an electrode should not be able to conduct electricity. Inertness was more commonly stated; others mentioned low reactivity, which was insufficient to gain credit.

(iv) This was answered quite well. Ion was the most common incorrect answer. Copper was seen occasionally.

Question 3

(a) This was answered extremely well.

(b) This was answered extremely well.

(c) This was answered quite well. The higher percentage of lead was sometimes incompletely stated as a reason. More lead (unqualified) or higher yield were both insufficient to gain credit.

(d) This was answered quite well. The most common error was to include oxygen as a reactant. The formula of lead(II) carbonate was occasionally seen as $Pb(CO_3)_2$.

(e) Only a minority of candidates performed well here. The formulae of lead(II) nitrate and/or nitric acid were commonly incorrect. Carbon dioxide was sometimes omitted as a product. Hydrogen was occasionally seen as a product.

(f) (i) This was done reasonably well. Double bonds were sometimes absent.

(ii) Those who realised that lead(II) oxide was ionic, sometimes contradicted this by referring to intermolecular forces or bonds between atoms or between ions and electrons. Many stated that covalent bonds are weak. Only a few candidates referred to forces of attraction between molecules in carbon dioxide.

(g) Very few wrote a correct ionic equation for Experiment 1. Candidates would benefit from more practice with ionic equations. Most were correct in writing no reaction for Experiment 2.

(h) (i) This was answered quite well. A common error was to refer to a burning splint relighting.

(ii) Candidates found this to be extremely challenging. Nitrogen was the most common wrong answer. Ammonia was occasionally seen.

Question 4

(a) This was answered extremely well.

(b) This was answered quite well. Silicon(IV) oxide was the most common incorrect answer.

(c) (i) This was answered quite well; others left this unanswered or omitted to use the Avogadro constant. Some multiplied the Avogadro constant by 22 without calculating the number of moles.

(ii) Candidates found this challenging. 24 dm^3 was rarely used to calculate the number of moles.

Question 5

(a) (i) Candidates found this challenging. Reference to either colour or end-point was expected.

(ii) This was answered well. Phenolphthalein or methyl orange were the most commonly correct acid base indicators**.** Potassium manganate(VII) was a common incorrect answer.

(b) Candidates found this challenging. Some described the titration being carried out despite being instructed not to. Several mentioned removing the indicator by fractional distillation. Many described heating but omitted to mention when to stop. Many omitted leaving the solution to crystallise. Drying was often mentioned without a description of how it should be done.

(c) (i) This was answered reasonably well. Orange was the most common incorrect answer.

(ii) Candidates found this the most challenging question on the paper. Answers given were only occasionally observations. Many confused this with the test for copper(II) ions using aqueous sodium hydroxide and described a blue precipitate, which either dissolved in excess or remained insoluble.

(iii) This was answered quite well. Evolution of sulfur dioxide was occasionally mentioned.

Question 6

(a) This was answered very well.

(b) (i) Candidates found this very challenging. Those that mentioned the evolution of oxygen gas sometimes omitted to mention that the gas escaped from the flask**.** Many candidates did not understand the principle of conservation of mass, suggesting that the loss in mass was due to all of the reactants being used up. Loss of mass can only occur if matter escapes from the flask.

Many suggested that the rate becomes constant (instead of the rate becoming zero) when the graph levels off.

(ii) The key to answering this question correctly was to realise that the rate is highest at the start, decreases as time increases and then becomes zero because the reaction stops. Some candidates stated that the rate increased and some added that this was because a catalyst is present.

The command word ‘describe’ is different in its requirements to ‘explain’. Although many responses referred to collision theory, this was unnecessary in a ‘describe’ question.

(c) (i) Most candidates realised that the particles gain energy at a higher temperature, which leads to a greater collision frequency. Far fewer candidates referred to a greater proportion of molecules having enough energy to react when they collide. Some stated that more collisions occur without reference to frequency or time.

(ii) This was answered reasonably well. The graph should have been steep at the start (because the rate is larger) and level off at the same mass (because the same amount of oxygen is evolved).

Question 7

(a) This was answered reasonably well. Some candidates stated ‘same molecular formula’ or ‘same structures’. Some answers were vague.

(b) (i) This was answered reasonably well. Polymerisation was a common incorrect answer.

(ii) Ethene was often missing from the products. The requirement to read the question carefully should be stressed repeatedly. Some formulae, e.g. C_3H_7, were unviable molecules. Ethene was often represented as C_4H_8.

(iii) Only a minority of candidates answered this correctly. Ethene was sometimes missing.

(iv) This was answered quite well. Names of other industrial processes were occasionally seen.

(v) Conditions were often vague, e.g. high temperature or pressure. Some thought steam was a condition.

(c) Candidates found this challenging. Vague answers such as less pollution / renewable resources / more environmentally friendly / less waste / cheaper were much more common than anything specific.

(d) (i) This was answered quite well. Addition, halogenation and displacement were seen occasionally.

(ii) This was answered quite well. Condensation and additional were the most common wrong answers.

(iii) This was answered quite well. A section of a polymer should never have brackets with or without an n subscript. Some candidates only drew one repeat unit. Extension bonds were sometimes missing.

(e) Candidates found this challenging. Those who drew a carboxylic acid group often missed out the O-H bond.

CHEMISTRY

Paper 0620/51
Practical Test

There were too few candidates for a meaningful report to be produced.

CHEMISTRY

Paper 0620/52
Practical Test

Key messages

- Candidates should go through their plans when answering **Question 3** before writing their response. Otherwise, extra sentences often need to be inserted to cover missing points realised later.
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit cannot be awarded.
- Candidates should be aware that the mark allocation reflects the number of valid points to be made for parts of questions.

General comments

Most candidates successfully completed all three questions and there was no evidence that candidates were short of time. The complete range of marks was seen, with some candidates performing very well.

Supervisors' results were submitted by all centres with the candidates' scripts. These results are used when marking the scripts to check comparability in **Questions 1** and **2**.

Some comments were submitted by supervisors after carrying out the experiments. The results obtained by some supervisors and candidates in **Questions 1** and **2** suggested that some centres did not use the materials specified in the Confidential Instructions. It is the responsibility of the centre to make sure that the appropriate chemicals and apparatus are provided for the examination. For example, the aqueous chlorine and aqueous bromine in **Question 2** should have been tested before the examination.

Comments on specific questions

Question 1

(a) A significant minority of candidates appeared to have little experience of using a burette and could not read the volumes. The commonest error was recording volumes as whole numbers such as $8\,cm^3$ or $0\,cm^3$. Candidates should realise that burettes measure volumes to (at least) one decimal place. Therefore, the expected readings would be $8.0\,cm^3$ or $0.0\,cm^3$.

(b) The colour change for methyl orange was well known.

(c) Only about half of the candidates observed bubbles or fizzing.

(d) (i) This was generally correctly answered. Most candidates realised that a larger volume of acid was used in Experiment 1, but fewer went on to give a quantitative answer, such as it was twice as much.

(ii) Most could explain the difference in volumes was because of the different concentrations of the acids. Vague reference to different solutions or strengths of acids were common.

(e) Most candidates could not deduce the volume of solution **L** needed.

(f) This was well answered. Most knew that the burette was rinsed to remove contaminants from the previous experiment.

(g) Vague answers referred to drying the burette. Few understood that the burette should then be rinsed with solution **L** to remove the remaining water, which would otherwise dilute solution **L** when placed in the burette.

(h) The use of a white tile to make the colour change of the indicator more obvious gained credit. A range of incorrect answers referred to 'stopping heat losses', 'improving the stability of the flask'.

(i) Repeating the experiments alone does not improve the reliability of the results. If the results are compared and found to be similar, or if anomalies are discarded, then the results are more reliable.

(j) The use of a measuring cylinder was known to cause inaccuracies and most went on to replace it with a pipette or burette. Vague references to reading errors were common.

Question 2

Solid **O** was ammonium bromide.

(a) Candidates found it difficult to describe the sublimation of the ammonium bromide.

Many candidates observed smoke, gas, or fumes, but few detailed that it was white smoke. Similarly, many reported condensation on the sides of the boiling tube but did not describe it as a white solid.

(b) Most realised that there was no reaction with aqueous sodium hydroxide.

(c) The majority of candidates identified ammonia and tested for it correctly.

(d) Many candidates reported the formation of a cream precipitate. A significant number stated that the precipitate would be white, cream-yellow, or white cream and gained no credit.

(e) Only a minority of candidates described that the solution went yellow or orange as bromine was displaced. Effervescence and formation of precipitates were common guesses.

(f) Many candidates correctly identified the presence of one of the ions in solid **O**, with some identifying ammonium bromide.

Liquid **P** was cyclohexene.

(g) Fresh bromine water was decolourised as expected.

(h) Most candidates observed a flame or the liquid burning.

(i) Expected colour changes were purple to green and then brown. Many candidates gained full credit.

(j) The most common answer seen was that '**P** was flammable'. A number of candidates recognised that **P** was an alkene or an unsaturated hydrocarbon.

Question 3

Candidates were asked to plan an investigation to obtain a sample of cobalt metal from a carbonate ore.

The complete range of marks was seen in this planning question.

A large number of candidates attempted to make crystals of a cobalt salt from reacting the ore with a dilute acid, which was often not named. A lot of candidates mistakenly assumed that the filtration of the salt solution or crystallisation of the salt solution would produce a sample of cobalt metal and gained few marks. Many did not crush the lump before starting, using a pestle and mortar.

Methods that would work were reduction and electrolysis and some good descriptions were given. Methods involving displacement by a more reactive metal often wrongly used copper or sodium.

A minority of candidates used the wrong method such as fractional distillation or chromatography. These methods showed a lack of knowledge and understanding.

A significant number of candidates did not attempt the question.

CHEMISTRY

Paper 0620/53
Practical Test

Key messages

- When recording quantitative data, all readings from a given piece of apparatus should be recorded to the same number of decimal places.
- When plotting graphs, candidates should use a cross (x) or an encircled dot (⦿) to indicate data points; very small dots which are hidden by the graph line are not suitable. Graph lines should be drawn using a sharp pencil and not a pen, as if an error is made the line, if drawn in pen, cannot be erased. Curves of best fit should not have sections drawn using a ruler. Graph scales should be chosen such that the plotted data takes up over half of the available space and it is recommended that each major grid line should be equivalent to 1, 2, or 5 (or those numbers multiplied by 10^n) – this is indicated in the mathematical requirements in the syllabus and by the Association for Science Education (A.S.E.).
- In qualitative analysis, when a reagent is added dropwise and then in excess, there should be an observation given for the dropwise addition and then another observation for when the test reagent is added in excess.
- Candidates must read the questions carefully. If a question asks for observations, then a conclusion will not gain credit, likewise if a conclusion is asked for, an observation will not gain credit.

General comments

Fully correct answers were seen to all question parts. The paper discriminated successfully between candidates of different abilities and very few blank spaces were seen.

Some responses might suggest that candidates have limited practical experience, possibly due to the unusual circumstances over the last two years. This was particularly true on **Question 2**, the qualitative analysis question and **Question 3**, the planning task.

It should be noted that solutions are always clear, although they can also be coloured. If a solution becomes cloudy during a qualitative test, it is because a precipitate has been formed.

Comments on specific questions

Question 1

(a) Almost all candidates were able to give acceptable results from the experiment, showing that the temperature increased during the reaction. Most candidates were able to calculate the temperature change using the equation given. A small minority of candidates calculated the temperature change in each 30 second interval rather than from the initial temperature.

(b) Almost all candidates were able to give acceptable results from the experiment, showing that the temperature increased during the reaction, with an increase lower than that seen in Experiment 1. Most candidates were able to calculate the temperature change using the equation given. A small minority of candidates calculated the temperature change in each 30 second intervals rather than from the initial temperature.

(c) Most candidates selected an appropriate graph scale. Some candidates selected a scale that was inappropriate either because the points plotted did not extend over halfway up the *y*-axis or with each major grid line being an awkward number (such as 7; which would mean each minor gridline was equal to 0.7 and so made plotting very difficult). There were some slips in plotting and some candidates did not label their lines.

(d) Most candidates were able to obtain a correct reading from their graph. The most common errors were to either not show any construction work on the grid or to read from the wrong line.

(e) While most candidates realised that the reaction would have stopped after five hours, some thought the temperature would either remain constant or would fall to an improbably low level, rather then return to room temperature. The initial temperatures of the solutions in each experiment should have been room temperature and so if candidates stated a temperature, rather than wrote 'room temperature', this temperature should have been the same as the initial temperature they had given in the experimental results.

(f) (i) Most candidates correctly stated that polystyrene was a poor conductor of heat or was an insulator. However, some incorrectly stated that glass would break or would melt at the temperatures involved.

(ii) Most candidates correctly stated that the temperature changes would be smaller or that the temperatures reached would be lower. Vague answers, such as 'the temperature would be different' did not gain credit.

(g) Most candidates focused on the use of a more accurate item of apparatus to measure the volume of aqueous copper(II) sulfate, such as a volumetric pipette or burette, or on reducing heat loss further by placing a lid on the polystyrene cup. Answers based on using a more accurate example of apparatus already used (such as a more accurate thermometer of measuring cylinder) did not gain credit.

Question 2

Solid **S** was calcium carbonate.

(a) Most candidates correctly noted the bubbles seen when dilute hydrochloric acid was added. The question instructed candidates to test the gas produced. This required candidates to report a positive test and the resulting gas produced. As there was effervescence when an acid was added, candidates familiar with qualitative analysis should have suspected that carbon dioxide was made and so tested the gas using limewater.

(b) While many candidates gained both available marks, some did not note that a precipitate was made or that the precipitate remained when aqueous sodium hydroxide was added in excess.

(c) Most candidates were able to identify solid **S** as calcium carbonate.

Solid **T** was iron(III) chloride.

(d) (i) Most candidates correctly noted the formation of a brown or red-brown precipitate and that the precipitate remained when excess aqueous sodium hydroxide was added. 'Red' alone is not acceptable as a colour for a precipitate of iron(III) hydroxide.

(ii) Candidates were expected to note both effervescence and the formation of a brown or red-brown precipitate. While many candidates noted one of these two points, only the stronger responses noted both.

(iii) The majority of candidates noted the bubbling seen but much fewer noted that the magnesium becomes darker or that the solution becomes warm.

(iv) The instructions told candidates to leave the mixture to stand for 5 minutes. The reason for this is that it allows the precipitate to settle out and the fact that it is white becomes more obvious; a common error was to state that the precipitate was yellow – this could well be due to not letting the mixture stand as instructed.

(e) Many correct identifications were seen. Some candidates did not give the oxidation state of the iron ion.

Question 3

The first line of the question told candidates that catalysts both speed up reactions and that they are unchanged at the end of the reaction. Candidates were expected to address both of these points in their experimental plans.

To show that copper(II) oxide increased the rate of the decomposition of hydrogen peroxide, candidates needed to devise an experiment to measure how quickly oxygen was made both with and without copper(II) oxide. Common approaches were to time how long it took to make a certain volume of oxygen or measure the volume of oxygen made in a set time. No credit was given for measuring how much water was made as the hydrogen peroxide was stated to be an aqueous solution already. To make the results of the investigation valid, variables such as the volume of aqueous hydrogen peroxide, must be controlled.

To show that copper(II) oxide was not used up, the mass of copper(II) oxide had to be measured before it was used and it had to then be recovered by filtration, dried and reweighed to show that it's mass had not changed.

Only the strongest plans took into account both rate and conservation of mass of copper(II) oxide. Most plans focused solely on the rate and some solely on the conservation of mass of copper(II) oxide.

CHEMISTRY

Paper 0620/61
Alternative to Practical

Key messages

- When plotting graphs, candidates should use a cross (x) or an encircled dot (⊙) to indicate data points, very small dots which are hidden by the graph line are not suitable. If (0,0) is a data point then it must be plotted on the graph. Graph lines should be drawn using a sharp pencil and not a pen, as if an error is made the line, if drawn in pen, cannot be erased.
- Observations are those which you can see. For example, 'fizzing' is an observation but 'hydrogen gas is produced' is not an observation as you cannot see that the gas is hydrogen.
- Candidates must read the questions carefully. If a question asks for observations, then a conclusion will not gain credit, likewise if a conclusion is asked for, an observation will not gain credit.

General comments

Candidates successfully attempted all the questions and fully correct answers were seen to all question parts. The paper discriminated successfully between candidates and very few blank spaces were seen.

Some responses might suggest that candidates have limited practical experience, possibly due to the unusual circumstances over the last two years. This was particularly true on **Question 3**, the qualitative analysis question and **Question 4**, the planning task.

Comments on specific questions

Question 1

(a) The vast majority of candidates were able to identify the apparatus as a conical flask. The most common incorrect answer was to identify it as a beaker.

(b) The majority of candidates were able to state an appropriate safety precaution to take when using dilute sulfuric acid; the wearing of goggles or gloves were the two most common acceptable answers. Credit was not given for answers such as 'take care not to spill it'.

(c) Better responses stated that the white tile made the colour change of the indicator easier to see. Common incorrect answers were based on protecting the bench or acting as heat insulation. Some candidates thought incorrectly that the tile was used to raise the flask to a suitable height. Candidates should be familiar with using a burette and the fact that the clamp the burette is held in can be adjusted for height.

(d) While many candidates were aware of the need to mix the contents of the flask in some way, a common error was to suggest a bung should be placed in the flask. This will not work as it would prevent any more acid being added and, in this case, would also lead to a build-up of pressure in the flask as a gas is produced.

(e) Most candidates were able to state that the burette is rinsed with water to clean it or remove residues from a previous experiment. Far fewer candidates were able to state why the burette then needs to be rinsed with dilute sulfuric acid to remove water, which would dilute the acid used in the burette. Common errors were to suggest the second rinsing was to remove even more impurities or to sterilise it.

Question 2

(a) Almost all candidates were able to give correct readings from the gas syringe diagrams. The most common error was to take each graduation shown to be 1 cm^3 rather than 2 cm^3.

(b) Almost all candidates were able to give correct readings from the gas syringe and thermometer diagrams. The most common error was to take each graduation on a gas syringe to be 1 cm^3 rather than 2 cm^3.

(c) Most candidates correctly plotted the values they recorded in the tables. Points should be shown as crosses (x) or encircled dots (⦿) rather than just as small dots, which become obscured by the graph line. As the syringe diagrams showed a volume of 0 cm^3 at 0 seconds, there should have been a point plotted at (0,0); omission of this point was common. While most candidates attempted to draw a smooth curve as instructed, some joined the points with straight lines or drew multiple lines.

(d) Most candidates gained both available marks. A common omission was to not show construction lines on the graph to show where the reading was taken. Other errors included reading from 110 seconds rather than 120 seconds or reading from the wrong graph line.

(e) The majority of candidates were able to connect the observation that the gas volume had stopped increasing with the fact that this meant the reaction had stopped.

(f) Stronger responses predicted a correct volume of 40 cm^3 and linked this to the fact that both experiments used the same quantities of reagents and so would make the same volume of gas.

(g) This question proved demanding for many candidates. Taking readings at shorter time intervals will result in more data being obtained. As more points can be plotted on the graph, it will be possible to draw a better line of best fit and so the trend can be seen more clearly. A common error was to state that if you took more readings then the data would be more accurate; this is not the case as any sources of error present when taking readings every 50 seconds will still be present if readings are taken every 25 seconds.

(h) The question asked for changes to the apparatus, hence answers based on repeating the experiment and finding mean values did not gain credit as that does not involve a change to the apparatus. The most common credit-worthy answer was to use a pipette or burette in place of the measuring cylinder. A significant number of candidates correctly suggested the use of a divided flask so that the bung does not need to be removed or insulating the reaction vessel. The use of a more accurate or digital thermometer was not accepted; the diagrams show that the thermometer used could be read to the nearest 0.5°C and this is sufficient and normal for laboratory thermometers. Digital thermometers, which have a resolution of 0.1°C, are rarely accurate to that level.

(i) Better responses were able to describe how the acid could be cooled to 1°C; the use of a fridge, freezer or ice bath being commonly seen. However, some candidates incorrectly suggest that just by not heating the acid the required temperature would be obtained. Vague statements such as ‘cool the acid’ did not gain credit as the question asked for a description.

Question 3

(a) The majority of candidates could suggest an appropriate pH. However, some candidates just stated the solution was ‘alkaline’, which did not answer the question. Answers such as a pH of >7 also did not receive credit as this has no upper limit and so could be an unsuitable value for a pH.

(b) Stronger responses correctly identified solution **Y**. However, the metal ion was often incorrectly identified as calcium, presumably due to the flame colour. It should be noted the flame test colour for calcium is an orange-red (or brick-red).

(c) While many candidates were familiar with the colour change shown by potassium manganate(VII) and were able to give a fully correct colour change, some candidates gave two colours - often more associated with acid-alkali indicators.

(d) Stronger responses were able to correctly name the gas. A common error was to identify the gas as sulfite.

(e) This question was well answered and many fully correct answers were seen.

(f) This question was well answered, although some candidates identified the gas as ‘ammonium’ rather than ‘ammonia’.

(g) Candidates find negative qualitative tests demanding. The test described was the test for sulfate ions; as the compound did not contain sulfate ions, candidates were expected to state that there would be no visible change. A common error was to state that a white precipitate was formed, which is the positive result for the sulfate ion test.

Question 4

Candidates who were familiar with the use of chromatography in the qualitative analysis of mixtures of colours were able to perform well on this question by describing how chromatography is carried out and how similar colours can be identified by the use of R_f values, or a simple comparison of the distance moved during chromatography. A common error was to melt the sweet prior to chromatography rather than dissolve it in water or another suitable solvent. Some candidates tried a variety of other inappropriate separation techniques, such as fractional distillation, or assorted chemical tests, despite having no information regarding the chemical properties of tartrazine.

CHEMISTRY

Paper 0620/62
Alternative to Practical

Key messages

- Candidates should go through their plans before writing their response when answering **Question 4**. Otherwise, extra sentences often need to be inserted to cover missing points realised later.
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit will not be awarded.
- Burette readings should be recorded to at least one decimal place.
- Candidates should be aware that the mark allocation reflects the number of valid points to be made for parts of questions.

General comments

The majority of candidates successfully completed all questions and there was no evidence that candidates were short of time. The complete range of marks was seen with some candidates performing very well. The paper discriminated successfully between candidates of different abilities but was accessible to all.

Candidates in most centres are becoming more familiar with the planning task set in **Question 4**. Candidates would be well advised to plan out their answers before writing them as this will avoid steps being out of sequence.

Most candidates were able to complete tables of results from readings on diagrams and then handle the data obtained, as in **Question 2**.

Comments on specific questions

Question 1

(a) (i) Credit was awarded for correctly labelling the dilute hydrochloric acid and the marble chips.

(ii) A small number of candidates were confused and named a burette.

(b) Most candidates realised that the carbon dioxide would escape and would not be collected. Better responses explained that this was because it was denser than air and that it should be collected over water or using a gas syringe.

(c) Most candidates correctly drew a calibrated syringe to show how the gas could be collected and its volume measured. Collection over water using a measuring cylinder was acceptable. Incorrect answers using gas jars or test-tubes were prevalent.

(d) This was a good discriminating question. The best responses filtered off the chips, washing them and drying and weighing the unreacted chips. A significant number of other candidates detailed methods involving subtracting the final mass of the flask from the original mass, which showed a lack of understanding.

Question 2

(a) Almost all candidates correctly completed the tables of results from the burette diagrams. The commonest error was recording the initial volume in Experiment 1 as 8 cm^3 instead of 8.0 cm^3. A small number of candidates could not read the volumes and appeared never to have used a burette.

(b) The colour change for methyl orange was not well known, with many getting it the wrong way round.

(c) Good responses realised that the reaction was between an acid and a carbonate, so that fizzing / bubbles would be observed.

(d) (i) This was generally correctly answered. Most candidates realised that a larger volume of acid was used in Experiment 1 but fewer went on to say it was twice as much.

(ii) Few candidates could explain that the different volumes were because of the different concentrations of the acids. Vague reference to different solutions or strengths of acids were common.

(e) Most candidates did not deduce that double the volume of solution **L** would need double the volume used in Experiment 3.

(f) This was well answered. Most knew that the burette was rinsed to remove contaminants from the previous experiment.

(g) This was a good discriminating question. Vague answers referred to drying the burette. Few understood that the burette should then be rinsed with solution **L** to remove the remaining water which would, otherwise, dilute solution **L** when placed in the burette.

(h) The use of a white tile to make the colour change of the indicator more obvious gained credit. A range of incorrect answers referred to ‘stopping heat losses’ and ‘improving the stability of the flask’.

(i) Repeating an experiment alone does not improve the reliability of the results. If the results are compared and found to be similar, or if anomalies are discarded, then the results are more reliable.

(j) The use of a measuring cylinder was known to cause inaccuracies and most went on to replace it with a pipette or burette. Vague references to reading errors were common.

Question 3

(a) Many candidates gained credit for the observation that there would be no reaction.

(b)(i)(ii) The majority of candidates gave a correct observation and identified ammonia correctly.

(c) Many candidates reported the formation of a cream precipitate. A significant number stated that the precipitate would be cream-yellow or white cream and gained no credit.

(d) Only a minority of candidates knew that the solution would go yellow or orange as bromine would be displaced. Effervescence and formation of precipitates were common guesses.

(e) Many candidates incorrectly identified the presence of sodium in liquid **P** from the flame colouration. A number recognised the presence of an unsaturated organic compound / alkene from the result of the aqueous bromine test. References to metallic ions were common.

Question 4

The complete range of marks was seen in this planning question.

Candidates were asked to plan an investigation to obtain a sample of cobalt metal from a carbonate ore.

A large number of candidates attempted to make crystals of a cobalt salt from reacting the ore with a dilute acid, which was often not named. Many candidates mistakenly assumed that the filtration or crystallisation of the salt solution would produce a sample of cobalt metal. Many did not crush the lump before starting, using a pestle and mortar.

Methods that would work were reduction and electrolysis, and some good descriptions were given. Methods involving displacement by a more reactive metal often wrongly used copper or sodium.

A minority of candidates used the wrong method such as fractional distillation or chromatography. These methods showed a lack of knowledge and understanding.

A significant number of candidates did not attempt the question.

CHEMISTRY

Paper 0620/63
Alternative to Practical

Key messages

- Observations are those which you can see. For example, 'fizzing' is an observation, whereas 'a gas was given off' is not.
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit will not be awarded.
- Laboratory thermometers can measure temperatures to 0.5 °C, so temperatures should be recorded to one decimal place, e.g. 49.0 °C and 49.5 °C rather than 49 °C.
- When plotting graphs, candidates should use a cross (x) or an encircled dot (⊙) to indicate data points. Very small dots which are hidden by the graph line are not suitable. Graph lines should be drawn using a sharp pencil and not a pen, as if an error is made the line, if drawn in pen, cannot be erased. Curves of best fit should not have sections drawn using a ruler.

General comments

The vast majority of candidates successfully attempted all of the questions and the full range of marks was seen. The paper discriminated successfully between candidates of different abilities but was accessible to all. The paper was generally well answered, with very few blank spaces

This session, **Question 4** was a planning task based on testing whether or not copper(II) oxide was a catalyst for the decomposition of hydrogen peroxide. Nearly all candidates managed to at least start the investigation, but few gained full credit. Candidates found this planning question particularly challenging.

Most candidates were able to complete tables of results from thermometer diagrams in **Question 2**. Some problems were caused by readings that were not whole numbers. Candidates should realise that thermometers measure to 0.5 ºC.

Some responses might suggest that candidates have limited practical experience, possibly due to the unusual circumstances these last two years.

Comments on specific questions

Question 1

(a) The two pieces of apparatus that had to be identified were well known. Most candidates recognised a conical flask and a gas syringe. There were a few other pieces of laboratory apparatus mentioned, such as beaker, pipette and burette.

(b) Most candidates appreciated that manganese(IV) oxide was the residue. Some candidates made the mistake of just using manganese or a different compound of manganese.

(c) Drawing an arrow where heat should be applied was comparatively straightforward for the majority. The most common mistake was heating the right-hand flask.

(d) (i) This was poorly answered with many parts of the apparatus being circled.

(ii) Many candidates did not appreciate the effect of the error, suggesting that there would still be some gas collected.

Question 2

(a) Candidates were generally very good at reading the scales. The three readings 49.5, 46.5 and 41.5 were the ones that were most commonly incorrect.

(b) These readings and subtractions were correct in most cases. Most candidates did not record the values to one decimal place, missing out on the third mark.

(c) Graphs were well presented by most candidates. Nearly everyone selected a scale of one large square equivalent to 5 cm^3 on the *y*-axis. A small number made the graph harder by using a scale such as 6 or 7 cm^3 to one large square. This made it harder to plot accurately and inevitably led to plotting errors. There were very few examples of dot-to-dot lines, with most candidates making a good attempt at a smooth curve. A small percentage of candidates plotted temperature, rather than temperature change, using a *y*-axis up to 60 °C.

(d) Those who used unsuitable scales on the *y*-axis often struggled to read the correct value.

(e) A large proportion of candidates could appreciate the reaction would have finished and that the solution would fall back to room temperature. The most common error was to assume that the temperature would continue to fall at the same rate for 5 hours, leaving some answers well below room temperature.

(f) (i) This was well-answered with candidates appreciating that polystyrene was an insulator and would reduce heat loss.

(ii) This caused confusion with some candidates thinking the direct opposite to the required answer of ‘lower temperature’ or ‘smaller temperature change.’ Vague answers, such as ‘the temperature would be different’ did not gain credit.

(g) Most candidates appreciated that a burette or pipette could be used because it is more accurate than the measuring cylinder used in the question. A much smaller number of candidates explained that a lid would reduce heat loss. Answers based on using a more accurate example of apparatus that was already used, such as a more accurate thermometer of measuring cylinder, did not gain credit.

Question 3

(a) The vast majority of candidates appreciated that carbon dioxide would turn limewater milky or cloudy.

(b) A wide range of compounds were given as answers to this question; calcium carbonate was the most common. A very small proportion realised that it could a different Group II metal carbonate, such as magnesium carbonate or barium carbonate.

(c) The majority of candidates appreciated that iron(III) hydroxide would form and described it correctly as a brown or red-brown precipitate that was insoluble in excess sodium hydroxide. ‘Red’ alone is not acceptable as a colour for a precipitate of iron(III) hydroxide.

(d) Many candidates appreciated that the addition of ammonia solution would also form a brown or red-brown precipitate of iron(III) hydroxide. A significant minority answered, ‘no change’, possibly thinking that the aqueous ammonia was being added to the precipitate in **(c)**.

(e) Nearly all candidates appreciated that this was a test for a chloride and that a white precipitate of silver chloride would form.

(f) A large proportion of candidates realised that the test for a sulfate would not give a positive result when testing a chloride.

Question 4

Candidates gave lengthy descriptions of two experiments covering the decomposition of hydrogen peroxide both with and without a catalyst. Many descriptions lacked key details that were required as mentioned in the first sentence of the question. This mentions that a catalyst speeds up a chemical reaction AND is unchanged in the process. Most candidates focused only on the fact that a catalyst speeds up a chemical reaction. They did not refer to filtering, drying and re-weighing the copper(II) oxide and the two-part conclusion mentioning increased rate and unchanged mass.

As this IS a quantitative investigation, weighing the initial **mass** of copper(II) oxide and measuring the **volume** of hydrogen peroxide were essential features that needed to be included.

Often there was no clear description of how the decomposition would be measured. Those who did refer to this measured the volume of gas over a set period of time, or measured the time taken until effervescence stopped. Stating that the reaction was timed until it stopped decomposing was insufficient to gain credit.