CHEMISTRY

Paper 0620/11
Multiple Choice (Core)

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

General comments

Candidates found **Questions 3**, **14**, **22** and **35** to have the least demand. Candidates found **Questions 10**, **25**, **33** and **37** the most demanding. All candidates found use of chemical properties to deduce the identity of a substance, such as **Questions 17**, **25** or **33**, difficult.

Comments on specific questions

Question 8

The distribution of options suggested guessing by some candidates.

Question 9

Many of the candidates chose option **C**. These candidates recognised the value should be multiplied by two but did not include the nitrogen atom in the calculation.

Question 10

All candidates found this a difficult question. The most common error was to think that a metal (sodium) would form at the cathode in the electrolysis of aqueous sodium chloride rather than hydrogen.

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Question 11

Few candidates chose option **A**, but options **C** and **D** were common incorrect answers showing candidates were most likely to confuse the role of aluminium in overhead electricity cables.

Question 17

Candidates found this question difficult and there was evidence of guessing. The acidic nature of options **A** and **D** were mostly well recalled, suggesting that the displacement of ammonia from ammonium was not well remembered.

Question 25

All candidates found this question difficult. The most common answer was option **A**. Candidates found it difficult to recall the three key reactions of metals: with water, with dilute acid and the reaction of the oxide with carbon.

Question 27

Although most candidates answered this correctly, over a third of candidates chose option **D**, indicating some confusion between the terms conductor and insulator.

Question 30

Only a third of candidates gave the correct response. In this question, statement 2 was an incorrect statement present in three of the options. This suggests that NPK fertilisers were not well recalled.

Question 33

This question was the least well answered on the paper. Many candidates chose option **A**. It is important that candidates read through all the information given. In this question, the third statement should give a strong piece of evidence to lead to the correct answer.

Question 36

Candidates who performed less well were more likely to choose one of the distractors rather than the correct answer.

Question 37

Candidates did not recall the structure of poly(ethene) well. Option **C** was the most common answer. Candidates should check the bonding in organic compounds as many could not recall that carbon only makes four bonds.

Question 39

The most common incorrect answer was option **A**, where candidates thought that all petroleum fractions were used as fuels.

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Paper 0620/12
Multiple Choice (Core)

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

General comments

Candidates found **Questions 14** and **19** to have the least demand. Candidates found **Questions 10**, **15**, **27**, **32** and **36** the most demanding.

Comments on specific questions

Question 1

This question tested candidates understanding of physical changes. Most candidates identified sublimation but option **B**, evaporation, was a common incorrect answer.

Question 3

This question was generally well answered; a few candidates chose option **A**. Lower performing candidates were more likely to choose option **B**.

Question 4

This question discriminated well. A few candidates chose option **D** and there was evidence of candidates guessing between the other three options.

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Question 7

More than a third of candidates chose option **B**, showing confusion between covalent and ionic bonding between Group I and Group VII elements. A significant number identified ionic bonding but confused the direction of electron movement.

Question 10

This question required candidates to recall the difference between the electrolysis of molten compounds and aqueous compounds. Most were able to identify one or the other, options **B** and **D**.

Question 12

This question discriminated well. A few candidates chose option **A** and there was evidence of candidates guessing between the other three options.

Question 15

Candidates found this a demanding question and the overall distribution was close to a guessing average. Candidates found it difficult to consider both the equivalent initial rate, which would eliminate options **A** and **D**, and the increased volume of CO_2 produced. The question stated that an excess of calcium carbonate was used in the first experiment, so the increase in mass would eliminate option **C**.

Question 18

The distribution of responses suggested guessing from some candidates.

Question 24

Most candidates answered this question correctly. Some candidates were more likely to suggest option **D**.

Question 27

All candidates found this question difficult. Half of the candidates incorrectly chose option **C**. Candidates should recall that unreactive metals do not react with water, but their oxides do react with carbon.

Question 32

All candidates found this question difficult and all distractors were popular, although option **B**, carbon dioxide, was the most common incorrect answer. Candidates should recall that a diatomic molecule has just two atoms.

Question 35

Options **B** or **C** were popular incorrect options. To answer this question, only the last syllable of the name is needed, '–ane'.

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Paper 0620/13
Multiple Choice (Core)

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

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CHEMISTRY

Paper 0620/21
Multiple Choice (Extended)

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

General comments

Candidates found **Questions 3**, **14**, **17**, **22**, **28**, **30**, **31** and **40** to have the least demand. Candidates found **Questions 21** and **25** the most demanding. Questions requiring deductions based on chemical information were found to be most difficult; these include **Questions 15**, **26**, **29** and **34**.

Comments on specific questions

Question 1

This question tested both understanding of diffusion and indicators. Option **A** was commonly chosen, especially by the weaker candidates.

Question 5

Option **C** was chosen by many candidates.

Question 6

Candidates who performed less well were more likely to choose options **A** or **C**, suggesting some confusion about the structure of silicon(IV) oxide.

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Questions 8, 10 and 12

These questions discriminated strongly between candidates. Those that performed less well were as likely to give any of the options.

Question 13

Some candidates were more likely to choose option **C**, which was a balanced equation for combustion of a fuel but not the equation for the fuel cell.

Question 15

A majority of candidates answered this question correctly, although a significant number chose option **D**. This suggests that many candidates were unclear about the role of activation energy in reaction rate.

Question 21

Only a third of candidates answered this question correctly. All the options were chosen although option **B** was most popular, suggesting that candidates confused ammonium and ammonia.

Question 22

This relatively straightforward question was well answered by most candidates; others chose option **C**.

Question 25

Most candidates recognised that sodium reacts with cold water but thought that copper reacted with dilute hydrochloric acid. Candidates are reminded that the least reactive metals form oxides which do react with carbon.

Question 29

Relatively few candidates chose options **A** or **D**. Almost a third chose option **C** suggesting some confusion between reaction rate and the position of equilibrium.

Question 34

Most candidates were able to eliminate option **D**. Candidates who performed less well tended to choose option **B**. Candidates are remined that they need to be able to give both the molecular and structural formula of the compounds listed.

Question 36

The distribution of answers from some candidates suggested some guessing.

Question 39

Option **C**, where both columns are incorrect, was the most common incorrect answer.

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CHEMISTRY

Paper 0620/22
Multiple Choice (Extended)

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

General comments

Candidates found **Questions 2**, **12**, **14** and **32** to have the least demand. Candidates found **Questions 9** and **13** the most demanding.

Candidates must take particular care when answering questions which contain a negative statement, such as ‘not’ or ‘cannot’. These were found in **Questions 30** and **34**.

Comments on specific questions

Question 1

Option **A** was the most common incorrect answer. Candidates must take care to read the whole question. The indicator was to turn red, which required an acidic gas.

Question 7

Some candidates chose option **B**, incorrectly assuming that Group I and Group VII elements form covalent bonds.

Question 9

The question was one of the most demanding question on the paper. Options **A** and **B** were both popular answers.

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Question 10

The question required candidates to recall the electrode product of two different electrolysis experiments. Some candidates chose one of the options, especially option **D**, which showed recall only of aqueous electrolysis.

Question 13

This was one of the more demanding questions on the paper. Candidates were required to recall how conditions change both reaction rate and the quantity of product produced. Option **A** was a common error.

Question 19

This question required candidates to use data on an unfamiliar compound to make a deduction about precipitation. All options were chosen equally, which suggested guessing.

Question 21

Fewer than half of the candidates were able to recall the role of the hydrogen ion in acidic solutions. Option **D** was the most common incorrect answer.

Question 23

Few candidates were distracted by option **A** or **C**. Option **B** was the most common incorrect answer, suggesting that the trend in density of Group I elements is not well known.

Question 30

Some candidates incorrectly chose option **C**.

Question 34

Some candidates were more likely to choose option **C**, which is a correct statement but does not answer the question.

Question 39

Candidates who performed less well were more likely to choose option **C**, where neither column of the table is correct.

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CHEMISTRY

Paper 0620/23
Multiple Choice (Extended)

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

General comments

Candidates found **Questions 14** and **23** to have the least demand. Candidates found **Questions 10**, **12**, **22**, **29**, **36** and **39** the most demanding. Overall candidates found this to be a challenging paper particularly in questions which required the use of numbers, such as **Questions**, **11**, **12**, **17** and **28** or organic chemistry, **Questions 34** to **40**.

Comments on specific questions

Question 3

Many candidates chose option **B**.

Question 10

This was one of the most demanding questions on the paper. Candidates were required to recall the electrode products in two different electrolysis reactions. All the options were popular. Option **C** was most commonly chosen by candidates who performed less well.

Question 11

This was a relatively demanding question. Option **B** was commonly chosen.

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Question 17

Candidates often find bond enthalpy questions difficult. A number of candidates chose option **B**. This answer has the opposite sign to the correct answer, suggesting that candidates confused the sign of energy changes during bond breaking and bond forming.

Question 21

Option **B** was a common incorrect answer. Candidates may have confused typical properties of transition elements with Group I elements.

Question 22

This question was one of the more demanding questions on the paper. Most candidates chose option **B**. Candidates predicted helium would have eight outer shell electrons which is incorrect.

Question 27

The most common answer was option **B**. Candidates should recall that oxides of nitrogen cause acidic rain whereas carbon monoxide is a neutral oxide.

Question 29

Slightly fewer candidates chose option **A**, but all the other options were as likely to be chosen as each other, suggesting guessing by many candidates. Candidates who performed least well were more likely to choose option **C**.

Question 30

Most candidates were unable to recall the catalyst used in the Contact process. All options were chosen, with option **C** being most commonly given.

Question 34

This was one of the more challenging questions, with almost a third of candidates choosing option **B**, confusing oxidation with dehydration.

Question 36

The distribution of choices suggests that guessing was common. The most common incorrect answer was option **D**, where candidates suggested than alkenes contain ionic bonds.

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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.
- Some candidates need more practice in answering questions about practical procedures.
- 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. Nearly all candidates were entered at the appropriate level. The standard of English was generally good. Some of the questions were left unanswered.

Some candidates need more practice in writing answers with the correct amount of detail and using or explaining specific chemical terms. For example, in **Question 2(f)(ii)** many candidates did not appear to know the difference between the separation and arrangement of particles. In **Question 2(f)(ii)**, many did not use the word 'diffusion' or refer to 'particles'. In **Question 4(b)**, attempts to explain the term 'unsaturated' were often hampered by vague statements. Many candidates need more practice in writing definitions. For example, in **Question 4(c)(i)** many candidates had difficulty in explaining the term 'polymer' and in **Question 5(c)(i)** many missed out the essential words 'compound' or 'only'. Others confused the terms 'elements' and 'compounds' at various points throughout the paper. In **Question 8(g)**, many candidates wrote about compounds of metals, rather than mixtures of metals, when asked to define the term 'alloy'.

Many candidates need more practice in analysing the stem of a question to pick out the essential words needed to answer the question. In **Question 2(a)(ii)**, many candidates did not use the information in the table as requested and hence gave the incorrect formulae for the ammonium and sulfate ions. In **Question 2(c)**, many did not heed the words 'other element' in the stem of the question and gave the names of compounds or potassium, which was in the stem of the question as an example. In **Question 3(b)(ii)**, many candidates gave medical uses of isotopes rather than industrial uses. In **Question 3(c)(ii)**, many candidates would be advised to specify exactly which substance is losing the oxygen and not just refer to elements which appear on both sides of the equation. Others just gave a definition of oxidation rather than referring to the equation. In **Question 7(a)(ii)**, some candidates referred to carbon or graphite, which had already been quoted in **(a)(i)** of this question. Candidates should be advised to look out for the word 'other' in a question so that they do not repeat what is in the stem.

Some candidates would benefit from further revision of specific topic areas such as organic chemistry (**Question 4**), atomic and electronic structure (**Questions 1(b)** and **7(b)**) and electrolysis (**Question 7(a)**).

Many candidates would benefit from learning specific practical procedures or observations. For example, in **Question 4(d)** many candidates did not write correct observations for the reaction of magnesium with acid. In **Question 5(b)(i)**, many candidates drew a series of closed or open containers or distillation apparatus instead of a gas syringe attached to a flask. Others did not label their apparatus or had large gaps for the gas to escape. In **Question 6(a)**, many candidates did not give precise information about how to measure the pH using universal indicator paper. Many gave colours relating to pH values rather than stating how to use the universal indicator solution by comparison with the colours on the indicator colour chart.

Some candidates need to revise qualitative tests for specific ions and molecules. The answers to the questions about the flame test for lithium ions (**Question 2(b)**), the test for calcium ions (**Question 5(a)(ii)**) and the test for water using anhydrous cobalt(II) chloride (**Question 5(d)(ii)**) were not well known.

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Some candidates were able to extract information from tables and graphs, balance symbol equations and undertake simple chemical calculations. Others need more practice in these skills.

Comments on specific questions

Question 1

This was the best answered question on the paper. Many candidates identified at least three of the substances correctly in **(a)**. In **(b)**, most candidates were able to deduce the correct number of protons and neutrons. The better performing candidates deduced the correct number of electrons as well.

(a) (i) Most candidates realised that atoms of Group II elements have two electrons in their outer shell. The commonest errors were to suggest **B** (four electrons in the outer shell) or **E** (seven electrons in the outer shell).

(ii) Nearly all the candidates correctly identified **D** as having 13 protons. The commonest error was to miscount the electrons and suggest **C**, which has 12 electrons.

(iii) Some candidates recognised that a Group VII element forms an ion with a single negative charge. The commonest error was to ignore the phrase 'forms a stable ion' and to suggest **A**, which has a single electron in the outer shell of the atom.

(iv) A minority of the candidates realised that **B** was carbon and therefore forms a giant covalent structure. The commonest error was to suggest **A**, which has the greatest number of electrons.

(v) Some candidates knew that aluminium is used to make food containers and identified the electronic configuration of aluminium. A variety of incorrect answers were seen, the commonest being **C** (magnesium).

(b) Some candidates did not appear to recognise the isotopic notation. The commonest errors in deducing the number of protons were to confuse the mass number and proton number or suggest that the calcium ion has 18 protons, even when the number of electrons was incorrect. The number of neutrons was usually correctly deduced, the commonest errors being to give the mass number or to add the number of protons to the mass number. Most candidates ignored the charge on the calcium ion and gave the number of electrons in an atom of calcium.

Question 2

Some candidates gave good answers to **(a)(i)**, **(a)(iii)** and **(d)**. In **(a)(ii)**, many did not use the information in the table and wrote incorrect formulae. Few knew the correct flame colour in **(b)** and in **(c)** only the better performing candidates gave the name of two elements commonly found in fertilisers. In **(f)**, many candidates need further practice in interpreting the properties of gases in terms of the kinetic particle model.

(a) (i) Many candidates selected the chloride ion as having the highest concentration in the fruit juice. The commonest error was to suggest 'potassium' through not reading the question carefully enough, selecting the positive ion rather than the negative ion.

(ii) A minority of the candidates gave the correct formulae. Others did not refer to the information in the table and wrote the formulae for sulfide ions or, for example, SO_2^- for sulfate. Another common error was to write NH_3 or N for ammonium. Others wrote the correct symbols but without the charges or with incorrect charges.

(iii) Many candidates did the calculation correctly using simple proportion. Others tried to use moles e.g. $\frac{200}{23}$ = 8.7 or $23 \times 2 = 46$. Candidates should realise there is no requirement to complete mole calculations in the core part of the syllabus. Other common errors were 80 (by taking 120 away from 200) or 24 000 (by mistakenly thinking that the concentration was in g/dm^3).

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(b) This was one of the least well answered parts of this question. Some candidates knew that a flame test was involved but most gave an incorrect flame colour, usually lilac or yellow. Others suggested adding water or doing electrolysis. A considerable number of candidates suggested using litmus or universal indicator paper, perhaps thinking of the alkaline solution formed when lithium reacts with water.

(c) A minority of the candidates realised that nitrogen and phosphorus were the other elements present in fertilisers. Some suggested potassium which was in the stem of the question. Others gave the names of compounds rather than elements e.g. phosphates. A majority of the candidates gave other elements such as calcium, sulfur or sodium. A considerable minority suggested water.

(d) This was the best answered part of this question. A small number of candidates suggested pH values other than 4; pH 7 being the commonest incorrect answer.

(e) Candidates found this challenging. A majority of the candidates gave the names of elements rather than compounds. Many of these elements were those found in fertilisers e.g. phosphorus, potassium. Calcium or sulfur were also commonly seen as incorrect answers. The commonest incorrect compounds seen were components of fertilisers e.g. nitrates.

(f) (i) The best answers referred to the arrangement of molecules being irregular and the separation being 'far apart'. A majority of the candidates did not appear to know the meaning of the term 'arrangement' and wrote answers relating to motion or separation of the particles. The degree of separation of the particles in a gas was often not well explained, with many candidates suggesting that the particles were 'separated' (which cannot be given because the word is in the stem of the question). Others wrote vague statements such as 'there is a lot of room' or 'they move from each other'. Many confused separation with motion.

(ii) A minority of the candidates gave good answers which referred to the random movement of particles by the process of diffusion. Many did not gain credit because they did not refer to particles or molecules but just stated that 'the hydrochloric acid moves', 'the gas spreads out' or 'the gas reacts with the litmus'.

Question 3

Many candidates did not gain credit in **(a)(iii)** because they wrote answers which were too vague. In **(b)**, few candidates gave a full enough answer to **(i)** and many gave medical uses of radioactive isotopes in **(ii)** rather than industrial uses. In **(c)(ii)**, only the better performing candidates realised that they needed to refer to oxygen loss from iron oxide rather than give a generalised definition of reduction.

(a) (i) Many candidates deduced the boiling point and atomic radius correctly. The commonest errors were to suggest that the boiling point of rubidium is less than 671 °C or that the atomic radius of potassium is less than 0.191 nm. A few candidates gave negative values for the atomic radius or boiling point.

(ii) The majority of the candidates referred to the correct trend. Some tried to link the melting point to the atomic radius, boiling point or reactivity of the elements.

(iii) Many candidates deduced the correct physical state but few gave a convincing reason. Some candidates suggested that the physical state was between a liquid and a solid. Fewer suggested that potassium is a gas at 60 °C. The reasons given were often too vague e.g. 'it's not yet changed to liquid' or 'it's not gone to its melting point'. The best answers referred to 60 °C being below the melting point. Some candidates suggested, incorrectly, 'below the boiling point'.

(b) (i) Many candidates just paraphrased the stem of the question and gave the simple answer 'the number of protons' without adding any qualifying statements such as 'in the nucleus of an atom'. Others wrote 'the number of protons in an element', which is not accurate enough because many elements have more than one atom in a molecule/giant structure.

(ii) The best answers referred to 'measuring thickness of the paper' or 'checking for leakages in the pipes'. A majority of the candidates referred, incorrectly, to medical applications, X-rays or batteries. Others wrote vaguely about explosions or bombs, which are not industrial uses.

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(c) (i) Many candidates were able to balance the equation. The commonest errors were to attempt to balance with 2NaOH, 6NaOH or to reverse the balance as 3Fe + 2 NaOH.

(ii) A minority of the candidates referred to oxygen being removed form the iron oxide. Some suggested that oxygen is being removed from iron, which is not accurate enough, since iron is on the right of the equation. Other just gave a definition of reduction as 'loss of oxygen' without referring to the equation as requested in the question. Candidates should be encouraged to read the question carefully to make sure they understand exactly what is being asked.

Question 4

Parts **(a)(ii)** and **(e)** were generally well answered. A minority of the candidates were able to identify the alcohol functional group correctly in **(a)(i)** or explain why compound **F** is described as unsaturated in **(b)**. In **(c)(i)**, some knew the meaning of the term 'monomer' but few could relate it to the formation of a polymer. A greater number of candidates could name the polymer of ethene but many gave the names of simple molecules. In **(d)**, many candidates knew the effect of an acid on litmus but very few described the correct observations when magnesium reacts with an acid.

(a) (i) A minority of candidates identified the alcohol functional group. The commonest errors were to circle the –COOH group or the –OH of this group or to include the CH next to the alcohol functional group. A considerable number of candidates included larger parts of the structure e.g. circling the top two carbon atoms and all the atoms attached.

(ii) Some candidates deduced the correct molecular formula. The commonest error was to include a functional group e.g. $C_3H_5O_3COOH$. Others did not count the number of each type of atom correctly, the commonest errors being to have fewer carbon or hydrogen atoms.

(b) 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. 'there is a carbon with a double bond' or 'there are double bonds' (without mentioning carbon-carbon). Others wrote even vaguer or incorrect statements such as 'the structure is not complete' or 'the compound is an alkene'.

(c) (i) Some candidates recognised that a polymer is made from monomers or small units. Others wrote statements about 'atoms combining' or 'polymers joining'. Few candidates wrote about polymers being long chain molecules or macromolecules. Some suggested 'giant structures' but this is too generalised. A considerable number of candidates did not respond to this question.

(ii) A minority of the candidates named poly(ethene) correctly. Most gave either examples of other polymers such as 'nylon' or monomers such as esters or ethene. A considerable minority gave the names of alkanes such as 'methane' or 'ethane'. A considerable number of candidates did not respond to this question.

(d) Some candidates knew that blue litmus turns red on addition of acid. Others suggested that litmus turns blue or brown. Very few candidates described the observations when magnesium reacts with ethanoic acid. Many focused on the products such as 'hydrogen is formed' (or more often the incorrect 'carbon dioxide is formed'). A considerable number of candidates gave colour changes of the solution or colour changes after litmus was added to the solution formed by reaction of magnesium with acid. Others suggested 'white precipitate'. A considerable number of candidates did not respond to this question.

(e) (i) Many candidates read the correct pH value from the graph. The commonest error was to suggest pH 4.2; the pH value when there is excess acid.

(ii) Many candidates deduced the volume correctly. A common error was to suggest 40 cm^3 (the volume at the far right of the graph), rather than focussing on the pH value at pH 7. Another common error was to suggest 11.6 cm^3, through not interpreting the values on the horizontal axis of the graph correctly.

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Question 5

Some candidates were able to define the term 'thermal decomposition' in **(a)**, describe the effect of change of concentration and temperature on rate of reaction in **(b)(ii)** and name the homologous series in **(c)(ii)** well. Very few candidates knew the test for calcium ions in **(a)(ii)** or drew a suitable diagram in **(b)(i)**. The meaning of the term 'hydrocarbon' was not well known in **(c)(i)** and in **(c)(iii)** a minority of the candidates were able to name two substances formed by the incomplete combustion of propane.

(a) (i) Many candidates realised that the word 'thermal' related to heating. Fewer described the word 'decomposition' as 'breaking down'. Many candidates simply repeated the word decomposition. Candidates should be advised that if there are two distinct words in a definition, both need to be defined. Some did not gain credit for heating because the word was used out of context e.g. 'heat is given out during the reaction'.

(ii) The minority of candidates who knew a test for calcium ions either gave the correct flame test or knew the results of the test using sodium hydroxide or ammonia. Those candidates who suggested a flame test general got the correct colour flame: brick-red. Those who opted for addition of aqueous sodium hydroxide often did not gain credit because they went on to suggest that the white precipitate is soluble in excess. A large number of candidates chose the wrong test reagent; silver nitrate being commonly seen. A considerable number of candidates did not respond to this question.

(b) (i) The best answers showed an accurate labelled drawing of a gas syringe with graduations and connected to a closed vessel. Some candidates drew apparatus that did not have anything resembling a plunger and was not labelled. Many candidates drew a measuring cylinder connected directly to the reaction flask. A significant minority did not draw a reaction vessel. Many candidates drew unworkable apparatus, including apparatus which allowed gas to escape into the air. A considerable number of candidates did not respond to this question.

(ii) Most candidates obtained partial credit for a description of the effect of change of concentration and temperature on rate of reaction. A minority referred to time taken rather than rate of reaction, whilst other candidates wrote answers in terms of the kinetic particle theory and did not mention rate of reaction.

(c) (i) Some candidates gave an accurate description of the term 'hydrocarbon' including the words 'compound' and 'only'. The commonest errors were to write about mixtures or molecules of hydrogen and carbon or to omit the essential word 'only' to imply that there are no other elements present. A considerable number of candidates suggested that hydrocarbons contain oxygen.

(ii) Many candidates were able to name the homologous series to which propane belongs. The commonest errors in terms of homologous series were to suggest either alkenes or alcohols. Others named specific compounds; 'hydrogen' or 'methane' were common incorrect answers. A considerable number of candidates did not respond to this question.

(iii) A minority of the candidates gave two correct products of incomplete combustion. Many candidates gained credit for either 'water' or 'carbon monoxide' but fewer chose 'carbon'. Many candidates suggested, incorrectly, that hydrogen is formed. Other suggested specific hydrocarbons.

Question 6

Most candidates identified at least one of the correct gases in the air in **(b)(i)** and gave the correct reason for the use of chlorine in water treatment in **(b)(iii)**. In **(a)**, few candidates were able to explain exactly how universal indicator paper can be used to determine pH. In **(b)(ii)**, better performing candidates were able to describe the idea of trapping larger particles while the smaller water molecules passed through the filter. The test for water using anhydrous cobalt(II) chloride in **(c)** was not well known; many candidates confused it with the test for water using anhydrous copper(II) sulfate.

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(a) Some candidates referred to dipping the indicator paper into the water. The majority of the candidates 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. A majority of the candidates just stated various colours that might be seen at different pH values e.g. 'if it's pH 4 the colour is red'. Others did not seem to know about universal indicator and just wrote about litmus changing from red to blue or blue to red.

(b) (i) A majority of the candidates were able to name at least one of the two main gases in the air. The commonest errors were to suggest either 'carbon dioxide' or 'hydrogen'.

(ii) Better performing candidates were able to describe the idea of trapping larger particles between the particles of sand while the smaller water molecules passed through the filter. Many candidates did not gain credit because they wrote about filter papers and the sand being trapped on the filter paper. A considerable minority thought that the question was about separating sand and stones or sand and insoluble particles. Others suggested, incorrectly, that the separation occurs because the insoluble particles 'stick to the sand'.

(iii) A majority of the candidates knew that chlorine kills bacteria/microbes. The commonest incorrect answers referred to 'acidifying the water' or the vague 'cleaning water'. Other vague answers were 'to kill pollutants' or 'to kill particles'.

(c) The test for water using anhydrous cobalt(II) chloride was not well known and many candidates confused it with the test for water using anhydrous copper(II) sulfate. Some candidates knew the colours 'blue' or 'red' in the appropriate place but few candidates knew both colours. Other common incorrect colours were 'orange' or 'colourless'.

Question 7

This was the least well-done question on the paper. Many candidates gave incorrect products at the electrodes in **(a)(i)**, sometimes giving elements or ions unrelated to lead or bromine. In **(a)(ii)**, a wide variety of elements other than platinum were given. In **(b)**, many candidates forgot that the first electron shell only contains a maximum of two electrons and added extra non-bonding electrons to one or both hydrogen atoms.

(a) (i) A minority of the candidates deduced that lead is formed at the negative electrode and bromine at the positive electrode. Many candidates wrote lead(II), which implies a lead compound, or lead ions instead of lead and bromide instead of bromine. Many candidates did not heed the statement about the lead bromide being molten and suggested oxygen or hydrogen forming at either electrode. A minority of the candidates wrote answers related to the electrodes rather than the electrode products e.g. 'cathode' and 'anode'; others gave observations.

(ii) A minority of the candidates suggested platinum. The commonest error was to suggest 'graphite' or 'carbon' despite the fact that the question asked for another substance (other than carbon). Many candidates suggested highly improbable electrode material such as 'carbon dioxide' or 'water'.

(b) Many candidates forgot that the first electron shell only contains a maximum of two electrons and added extra non-bonding electrons to one or both hydrogen atoms. Others gave the electronic configuration for hydrochloric acid instead of hydrogen and included the symbols H and Cl. A few candidates did not show the bonding pair of electrons and showed the two electrons as a non-bonding pair or as one non-bonded electron on each hydrogen atom.

Question 8

This was one of the better answered questions on the paper. Many candidates identified the properties of an element with simple covalent bonding in **(a)** and deduced the order of reactivity in **(e)**. Most candidates were able to write the symbol for a reversible reaction in **(f)**. In **(b)**, many candidates did not refer to metals whilst in **(c)** and **(d)** a minority of candidates gave convincing answers about the lack of reactivity of krypton and the difference between transition element and Group I metals. In **(g)**, many candidates did not gain credit because of either conflicting statements or vague answers.

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(a) Those candidates who knew the properties of simple covalent molecules usually gained full credit. A significant proportion of candidates suggested **P** and **R** rather than **Q** and **S** but some of these seemed to guess the properties and gave one correct answer related to simple covalent compounds.

(b) Many candidates suggested that element **T** forms a basic oxide. Few related this to metallic character. Common incorrect answers included ‘because its acidic’ or ‘because its reactive’.

(c) The best answers referred to a full outer shell of electrons. Common incorrect answers ranged from the vague ‘because it’s a noble gas’ to incorrect statements such as ‘it’s got no free electrons’.

(d) Many candidates gave one correct difference between transition elements and Group I elements. Few gave two differences. Many confused the differences, suggesting that sodium ‘has a high melting point’ or ‘sodium is denser’. Some candidates chose malleability or ductility but did not gain credit because they suggested that transition elements were not malleable or ductile rather than less malleable or less ductile. A significant number of candidates referred, incorrectly, to rusting or magnetism, properties which only apply to iron (for rusting) or iron, nickel and cobalt for ferromagnetic properties.

(e) Most candidates deduced the correct order of reactivity. The commonest errors were to suggest that nickel is less reactive than copper or to reverse the order completely.

(f) Nearly all the candidates were able to draw the correct symbol for a reversible reaction. The commonest error was to draw a single double-headed arrow. A few candidates drew a circle with an arrowhead.

(g) The best answers focused on a mixture of a metal with another element. Many did not gain credit because they did not write the essential word ‘mixture’ or contradicted themselves by including the word ‘compound’. A significant minority did not mention that one of the components has to be a metal.

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CHEMISTRY

Paper 0620/32
Theory (Core)

Key messages

- Candidates performed well on questions where they had to match the structure of atoms to a statement.
- Questions requiring simple answers to calculations were usually answered well, as were questions involving balancing equations.
- Responses to questions on the more detailed aspects of the kinetic particle theory need to contain a more focused explanation and attention to detail. Candidates need to think more carefully when constructing their answers. They must also make sure that they read back through their longer answers to ensure they make sense and include the correct chemical concepts and wording.
- Questions involving extended writing need to contain the same number of relevant points as the number of marks available. This also should be applied to any other question that has more than one mark available.
- It is very important that candidates read the question carefully in order to understand what exactly is being asked. The reading of questions properly and not quickly skipping through them became more evident this year. Some candidates would benefit from more practice reading and interpreting data-based questions.
- Most candidates need more practice on answering questions on the practical side of this course. The main practical question was to draw the apparatus to 'investigate the volume of carbon dioxide produced' (**Question 5(b)(i)**). The standard of apparatus drawn was poor and responses to these types of questions need to be practiced more. The answering of chemical test questions was very poor and showed large gaps in the knowledge of many candidates. This is a part of the syllabus that definitely needs to be practiced.
- Organic questions were answered reasonably well and some candidates could draw structures of organic compounds.

General comments

Many candidates tackled this paper well, showing a good knowledge of core Chemistry. Good answers were shown throughout the paper to a number of different questions, however, most candidates found parts of every question challenging with the longer questions, in particular, being poorly answered. Nearly all candidates were entered at the appropriate level but there were a few candidates gaining very low marks and leaving vast amounts of the paper blank. Better performing candidates use past paper practice as part of their revision program.

Misinterpretation of the rubric was seen in some cases. The most common, either misinterpretation or simply not reading of the rubric, was in the question that asked, 'describe the arrangement and motion of the particles in a solid'. Some candidates described separation of particles in a solid instead. However, not reading the question properly was a key factor of some making silly mistakes in their answers. Another misinterpretation question was **Question 8(b)** where it asked to 'Describe how the metallic character of the elements depends on their position in the Periodic Table'. Not many candidates understood what this question meant and did not take enough time to read it so did not put down an answer that could obtain any credit. The balancing of equations indicated that candidates had practised these as part of their revision from past papers. Definitions from across the syllabus were poorly done and candidates need to concentrate on them when being taught for the first time and during the revision period.

On the other hand, the vast majority of candidates were able to 'work out the number of neutrons and protons' in a given atom and ion but many candidates did struggle with 'working out the number of electrons in a stated ion'. Most candidates could compare differences in sets of data but still need to practise this, as in **Question 8(a)** when they needed to identify covalent molecules from different properties like melting points and electrical conductivity. Data handling type questions could have been answered better. Candidates did

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lose credit for slight mistakes and not being precise enough when answering questions. Candidates did struggle to draw the structure of an alkene which showed more practice is needed in the drawing of molecules listed in this part of the specification. Candidates, however, need to be more explicit when talking about certain concepts and not use the words 'it' and 'they' to answer questions as many lost credit here when answering. The standard of English was reasonably good. Some candidates wrote their answers as short phases or bullet points. Candidates are less likely to write vague statements or contradict themselves if this is done.

Comments on specific questions

Question 1

Candidates tackled this question reasonably well even though they struggled with **(a)(i)**, **(iii)** and **(b)**. Some candidates found it hard to work out the number of protons, neutrons and electrons in an atom and ion especially the number of electrons in a given ion, so more practice is needed here.

(a) (i) Candidates struggled with this question. Many did not know that the number of electrons in the outer shell corresponded to the group number in the periodic table.

(ii) Candidates knew that a full outer shell was a noble gas.

(iii) Candidates struggled to identify which atom this was so more practice on which atoms form certain ions is needed.

(iv) Most candidates could answer this question and knew about shells of electrons.

(v) This was answered well. Candidates could relate the number of electrons to proton number.

(b) Many candidates struggled to work out the number of protons, neutrons and electrons in the given atom and ion. This was especially prevalent in the working out of the number of electrons in the given ion and more practice is needed here when revising the syllabus content.

Question 2

Candidates struggled with this question especially **(a)(ii), (b)** and **(d)**. However, they tacked **(e)** and **(f)** well.

(a) (i) Most candidates could answer this well and had obviously practised this type of question from previous papers.

(ii) Some candidates could give the formulae of the ions needed in this question but there were a lot of candidates that could not. More practice of writing formulae and knowing what ions make up a formula is needed to be able to answer these sorts of questions.

(iii) This mathematical question was answered well and showed that candidates had practised this type of question.

(b) Candidates appear to struggle with the learning of the chemical tests that are in the syllabus. This question was very poorly answered, with many candidates giving completely the wrong test, getting mixed up between tests or not giving a chemical test at all. A few candidates got the correct test but then went on to put the incorrect observations; many had not learnt the chemical tests well enough.

(c) Candidates struggled to name the 'two other elements present in most fertilisers'. Many different elements were seen, including 'hydrogen' and 'oxygen' which were wrong and also species which are not elements like 'phosphate' and 'nitrate'. Candidates found it difficult to recall these.

(d) Candidates struggled with this question the most on the paper. Hardly any correct answers were seen. Candidates forgot to use the given chemical equation to identify the fact that water was also given off and so there was an observation here. Candidates should have observed this as part of a practical. Most candidates put down 'bubbles' as their observation.

(e) Most candidates could balance the equation.

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(f) The kinetic particle model question was answered well, showing that candidates are revising and understanding how to answer these types of questions. However, candidates must remember to use the words 'particles' or 'molecules' in their answers and not just put 'ammonia moved'. This question had three marks so candidates needed to answer with three points in order to gain full credit.

Question 3

Candidates coped well with this question especially **(a)(i)**, and **(b)**. Some found the uses questions more challenging and more revision is needed here.

(a) (i) Candidates did better on this question than in previous years showing that they had practised this type of question and understood it well. They coped well with the fact that the temperature scale was using negative numbers and predicted the boiling point of bromine. There were, however, some candidates who struggled with this scale and put down more negative numbers. Most candidates did get the density of liquid iodine correct and could write down a value in the correct range.

(ii) Most candidates could state 'increases' or 'gets darker' here. However, some candidates did not recognise that the wording of the question said 'trend' and just put 'black'.

(iii) The better performing candidates answered this question well and had obviously practised it when revising. Most candidates could say 'liquid' but could not explain why in enough detail to gain further credit. They need to talk about both the melting and boiling point here to full credit.

(b) Most candidates answered this question well and had revised the meaning of this term. Some did forget that the word 'atom' was needed and put 'molecule' instead.

(c) (i) The definition of 'nucleon number' was answered well showing good revision of the definitions and that candidates had taken the time to learn them. However, some candidates did get mixed up and used 'electrons' instead of the correct 'protons plus neutrons'.

(ii) Candidates did very well on this question and most knew the medical use. Some candidates did need to read the question properly though as they did not see the word 'medical' and put the wrong type of use.

(iii) A lot of candidates could answer the 'major use' of this radioactive isotope showing that some candidates are taking the time to revise the uses of species listed in the syllabus.

Question 4

Some candidates coped well on this question. Parts **(a)(i)** and **(ii)**, **(b)** and **(c)(ii)** were answered well, whereas candidates struggled with the other parts especially **(d)**. The observations part was poorly answered.

(a) (i) Many candidates got this correct showing more practice of identifying the organic groups listed in this syllabus is taking place during lessons.

(ii) Many candidates got this question correct. Occasionally, the numbers in the formula were not give as subscripts.

(b) This was a well answered question showing many candidates knew what 'sublimation' meant. Most candidates used the words 'directly' or 'without a liquid forming' in their answers, which showed much revision.

(c) (i) Some candidates did not know the name of the –OH functional group so could not state it. 'Hydroxide' was seen in a few instances but on the whole most candidates knew 'alcohol' or 'hydroxy'.

(ii) This was a well answered question. Most candidates knew that 'monomers' are 'the small molecules that react together to form a polymer'.

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(d) This observation type question was poorly answered. Some candidates knew that the 'blue litmus paper' would turn 'red' but not many knew that the 'calcium carbonate' would give 'bubbles'. When practicals are being carried out candidates should always be encouraged to make as many observations as possible recording them and processing them as they are carried out.

(e) (i) Candidates struggled to answer this question correctly. This was a reading off the graph question and more practice in class is needed here.

(ii) Some candidates were not precise enough when working out the scales of the graph and so did not gain credit.

Question 5

Some candidates found this question demanding, especially in drawing apparatus in **(b)(i)** and the drawing of the structure of the alkene in **(c)(i)**. Many found the 'definition' of 'incomplete combustion' very challenging **(c)(ii)**. Most candidates could identify the reversible reaction arrow in **(a)(ii)**.

(a) (i) Most candidates could 'name' a rock 'which is mainly calcium carbonate'. However, some candidates thought the rock was 'lime rock' instead of the correct 'limestone'.

(ii) This question was very well answered and most candidates could identify the symbol given as a 'reversible reaction'. There were a few candidates that called it a 'reverse' reaction and these candidates did not gain credit.

(iii) Candidates struggled with this question and it was obvious that they did not know any other uses of lime. Only a few candidates answered this question correctly.

(iv) This chemical test question was answered really well and most candidates knew the correct answer. Candidates that got the test always got the correct result. Some candidates did not know the test at all and put down tests that were for other species in the syllabus.

(b) (i) Candidates struggled with this practical based question. Some could not draw a suitable container (flask or boiling tube) and then could not connect it up properly to the shown syringe. Drawing of apparatus is something that needs to be practised by the candidates as part of their revision strategies.

(ii) This rate of reaction question was answered reasonably well by the candidates. Most candidates knew that the reaction would become 'slower' when the temperature was 'decreased' and 'faster' when 'calcium carbonate powder is used'. The use of these sorts of describing words was far better this year. Some candidates did refer to time in their answers which lost them credit.

(c) (i) Candidates struggled with this organic structures question. They were not able to add in the missing bonds and atom. Some tried to draw single bonded structures and missed out the double bond completely. Quite a few candidates put five bonds around the second carbon. More practice is needed on the drawing of the organic structures that are in this syllabus.

(ii) Candidates struggled, with this question with hardly any correct answers seen. Most did not know that 'incomplete combustion' was burning in 'limited oxygen'. This was a definition that most candidates had not revised.

Question 6

Candidates struggled with **(a)(ii)** and **(b)** the most on this question. Some candidates knew how to do dot-and-cross diagrams in **(c)(i).**

(a) (i) Most candidates knew the percentage of 'oxygen' in 'clean, dry air' and got this question correct, showing revision and learning.

(ii) Candidates did not do as well on this question and many did not know the correct gases. Gases like 'hydrogen' and 'carbon dioxide' were seen as answers even though the latter is not an element.

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(b) This was the question where most candidates lost credit. Candidates struggled with this question and most candidates could not identify the 'source' and 'adverse effect' of lead. Only a few candidates gained any credit here. Candidates did perform better with the same questions on sulfur dioxide.

(c) (i) Many candidates could draw the dot-and-cross diagram of water showing that these had been practised when revising. However, some candidates showed too many electrons on the hydrogen atoms and more than four non-bonding electrons on the oxygen atom.

(ii) Candidates struggled with this practical based question. A few candidates could answer the colour change correctly but many had no idea what the colour change was or got it mixed up with other practical colour changes listed in this syllabus.

Question 7

Candidates struggled with much of this question. They found the electrolysis of dilute sulfuric acid particularly challenging in **(a)** and struggled with the definition of 'covalent bond' in **(b)(i).**

(a) The answering of this electrolysis product prediction question was poor with many candidates not gaining any credit. This is a concept that can be easily practised by the candidates in class as part of their revision.

(b) (i) Only a few candidates got this question completely correct using the words 'shared pair of electrons'. Many candidates knew that it was 'shared electrons' but did not put in the word 'pair' to gain full credit.

(ii) Most candidates could say what the 'arrangement' and 'motion' of the 'particles in a solid' was. However, some candidates got mixed up with the 'separation' of the particles in a solid.

(c) Most candidates knew the answer for this question. There were a few candidates that incorrectly stated metals such as 'copper'.

Question 8

This was a reasonably answered question. Candidates answered **(a)**, **(c)** and **(e)** well but struggled with **(b)** and **(f)**.

(a) This was a reasonably well answered question. Most candidates could state which elements were covalent molecules with the correct reasons showing that this type of question had been practised. There were a few candidates that struggled identifying the correct elements though.

(b) Most candidates struggled with this question and not many correct answers were seen. Candidates found this question the hardest on the paper.

(c) This was a well answered question. Most candidates achieved full credit showing much knowledge of Group I and transition elements. However, as with other comparison questions, candidates should name the element that is being written about rather than just calling it 'it'.

(d) This question caused problems with some candidates who could not identify the stated oxide as a 'basic oxide' and also give a reason for their answer. Incorrect answers seen were 'it is a metal' instead of the correct, 'potassium is a metal'.

(e) This was answered well and showed that candidates had been practising this type of question. There were, however, a few candidates that got the sequence the wrong way round. Candidates must make sure that they take their time to read each question properly.

(f) Candidates struggled with this practical based question. Not many candidates knew that the answer was a 'green precipitate' and that it 'dissolves in excess'. All sorts of different colours were seen in this question. Practical aspects of this course need to be concentrated on when revising.

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CHEMISTRY

Paper 0620/33
Theory (Core)

Key messages

- Candidates would benefit by improving their knowledge of specific chemical terms and processes.
- Candidates need more practice in writing with precision.
- Candidates need more practice in answering questions about practical procedures, particle theory and environmental chemistry.
- Interpretation of data from tables and completion of chemical equations was generally well done.

General comments

Most candidates showed some knowledge of core chemistry. All the candidates were entered at the appropriate level. However, many of the questions were left unanswered.

Candidates need more practice in writing answers with the correct amount of detail, using or explaining specific chemical terms. For example, in **Question 7(c)** many candidates did not appear to know the difference between the separation and motion of particles whilst in **Question 2(f)(ii)** most did not use the word diffusion or refer to particles. Many candidates need more practice in explaining the effects of particular chemicals on the environment. For example, in **Question 5(d)** few candidates were able to explain how carbon dioxide contributes to climate change and in **Question 6(c)** most did not know a source of carbon monoxide and oxides of nitrogen, nor their effects.

Many candidates need more practice in analysing the stem of a question to pick out the essential words needed to answer the question. In **Question 2(a)(ii)**, many candidates did not use the information in the table as requested and hence gave the incorrect formulae for the sodium and nitrate ions. In **Question 2(c)**, many did not heed the words 'other element' in the stem of the question and gave the names of compounds or phosphorus, which was in the stem of the question as an example. In **Question 7(b)**, some candidates referred to carbon which had already been quoted in the stem of the question.

Most candidates would benefit from further revision of specific topic areas such organic chemistry (**Question 4**), atomic and electronic structure (**Questions 1(b)** and **3(b)**) and electrolysis (**Question 7(a)**).

Most candidates would benefit from learning specific practical procedures or observations. For example, in **Question 4(b)(iii)**, candidates did not write correct observations for the reaction of magnesium with acid. In **Question 5(c)(i)**, few candidates attempted to complete the apparatus for the collection of a gas and in **Question 5(c)(ii)** and **(iii)** candidates were unable to identify a measuring cylinder and a gas syringe.

Candidates need to revise tests for specific ions and molecules. The answers to the questions about the test for chloride ions (**Question 2(b)**), the test for an unsaturated compound (**Question 4(a)(i)**) and the test for oxygen (**Question 7(c)(i)**) were not well known.

Some candidates were able to extract information from tables and graphs, balance symbol equations and undertake simple chemical calculations. Others need more practice in these skills.

Comments on specific questions

Question 1

This was the best answered question on the paper. Many candidates identified at least three of the substances correctly in **(a)**. In **(b)**, most candidates were able to deduce the correct number neutrons. A minority of the candidates deduced the correct number of proton and electrons as well.

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(a) (i) Some candidates realised that atoms of Group VI elements have six electrons in their outer shell. The commonest errors were to suggest **B** (seven electrons in the outer shell) or **C** (four electrons in the outer shell).

(ii) All candidates correctly identified **E** as being a reactive metal.

(iii) All candidates recognised the atom with a proton number of 17.

(iv) A minority of the candidates realised that **D** was an ion with a 2− charge. The commonest error was to suggest **A**, which has two electrons in the first and only shell.

(v) Some candidates recognised the electronic configuration of an atom of oxygen. A variety of incorrect answers was seen.

(b) A few candidates gained full credit. Most others did not appear to recognise the isotopic notation. The commonest error in deducing the number of protons was to confuse the mass number and proton number or suggest that the fluoride ion has 10 protons. The number of neutrons was usually correctly deduced, the commonest errors being to give the mass number. Most candidates ignored the charge on the fluoride ion and gave the number of electrons in an atom of fluorine.

Question 2

Some candidates gave good answers to **(a)(i)**, **(a)(iii)**, **(c)(ii)** and **(d)(i)**. In **(a)(ii)**, many did not use the information in the table and wrote incorrect formulae. None knew the test for chloride ions in **(b)** and in **(c)(i)** only the better performing candidates gave the name of two elements commonly found in fertilisers. In **(d)(ii)**, many candidates need further practice in interpreting the diffusion of gases in terms of the kinetic particle model. A significant proportion of the candidates did not respond to **(b)** and/or **(d)**.

(a) (i) Every candidate selected the chloride ion as having the highest concentration in the fruit juice.

(ii) A minority of the candidates gave the correct formulae. Others did not refer to the information in the table and wrote the formulae for nitride ions, NH_3 or N instead of the formula for the nitrate ion. Others wrote the correct symbols but without the charges or with incorrect charges. The formula for the sodium ions was generally correct.

(iii) Some candidates did the calculation correctly using simple proportion. Others tried to use molar masses e.g. N = 2 × 14 = 28. Candidates should realise that there is no requirement for moles calculations in the core part of the syllabus. Another error was 1500 mg (by mistakenly thinking that the concentration was in g / dm^3).

(b) None of the candidates knew the test for chloride ions. Few attempted the question.

(c) (i) A minority of the candidates realised that potassium and nitrogen were the other elements present in fertilisers. Some suggested nitrogen which was in the stem of the question. Others gave the names of compounds rather than elements e.g. nitrates. A majority of the candidates gave other elements such as calcium, sulfur or sodium. Chloride and sulfate were also seen.

(ii) Most candidates realised that fertilisers improved plant growth. Some candidates wrote vague answers such as ‘to give nutrients to the soil’ or ‘to decompose in the soil’.

(d) (i) Some candidates gained full credit for balancing the equation correctly. Others wrote 3(NH_3) instead of 2(NH_3).

(ii) No candidate gained more than a single mark for this question. The best answers referred to the movement of particles. Neither diffusion nor the (bulk) movement of particles from high to low concentration were mentioned. Most candidates did not gain credit because they did not refer to particles or molecules but just stated that ‘the ammonia moves’.

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Question 3

Many candidates gained credit for **(a)(i)** and **(c)**. Others did not gain credit in **(a)(ii)** because they gave reasons which were far too vague. Few gave a correct dot-and-cross diagram for chlorine in **(b)**. A significant proportion of the candidates did not respond to **(a)(ii)** and/or **(b)**.

(a) (i) Many candidates deduced the melting point of chlorine and the density of fluorine. Most gave a suitable colour for astatine. The commonest errors related to a misunderstanding of how to deal with negative values for the deduction of the melting point.

(ii) Some candidates deduced the correct physical state, but none gave a convincing reason. The reasons given were often far too vague e.g. 'it's not yet changed to liquid' or 'it's not yet reached its boiling point'. Candidates should realise that for a liquid state, they have to refer to both the melting and boiling points as well as the stated temperature, in this case 0°C.

(b) Some candidates realised that there is a single bonding pair of electrons between each chlorine atom. Others drew two bonding pairs (four electrons). Others drew the incorrect number of non-bonding electrons.

(c) (i) Many candidates recognised that the number of nucleons decreases. Some did not gain credit because they suggested vaguely that 'the number of nucleons changes'.

(ii) Most candidates realised that not all isotopes are radioactive. The commonest error was to select the fourth box as being incorrect (isotopes of the same element have the same number of protons).

Question 4

Parts **(a)(ii)**, **(b)(i)** and **(c)** were generally well answered. None of the candidates were able to describe the chemical test for an unsaturated compound in **(a)(i)** or name the saturated hydrocarbon containing two carbon atoms in **(a)(iii)**. Some deduced the molecular formula in **(b)(i)** but none wrote the displayed formula of ethanoic acid correctly in **(b)(ii)**. In **(d)(i)**, none of the candidates named the –OH group correctly whilst in **(d)(ii)** few candidates recognised the addition reaction. A significant proportion of the candidates did not respond to **(a)(i), (a)(iii)**, **(b)(i)**, **(b)(ii)** and/or **(d)(i)**.

(a) (i) The test for an unsaturated hydrocarbon was not known. Some candidates wrote about physical processes such as distillation.

(ii) Most candidates gave a good description of a catalyst, including the fact that it is not used up in the process. Errors included 'it changes a reaction' and 'it starts a reaction'.

(iii) Some candidates identified ethane. Others gave the names of two carbon compounds which were not alkanes e.g. ethanol. Other candidates suggested name of elements e.g. chlorine.

(b) (i) Most candidates deduced the molecular formula correctly. The main errors involved miscounting the oxygen atoms or putting addition signs between the carbon, hydrogen and oxygen atoms.

(ii) Errors included drawing the structure of ethane and drawing structures with two carboxylic acid groups.

(iii) Some candidates gave a correct colour for the universal indicator. Others did not gain credit because they wrote about the pH rather than giving an observation. Some candidates did not give observations for the reaction of sodium with water but gave names of products. Other incorrect answers included, 'combusts' and 'changes colour'.

(c) (i) Some candidates deduced the pH correctly. Others did not read the volume with precision and gave values of 4 or 4.1.

(ii) Most candidates deduced the volume of aqueous ammonia correctly. The commonest error was to suggest 25 cm^3.

(d) (i) The name of the –OH group in alcohols was not known. Errors included 'oxygen hydroxide' and 'single bonds'.

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(ii) A minority of the candidates suggested addition. The commonest error was to suggest 'reduction'.

Question 5

In **(a)**, few candidates knew that limestone is calcium carbonate or knew that natural gas is mainly methane. In **(b)**, few candidates were able to name the products of the decomposition of calcium carbonate. In **(c)(ii)**, a minority of the candidates completed the diagram correctly and in **(c)(iii)** few knew the names of the apparatus. A greater proportion of the candidates were able to describe the effect of particle size and temperature on the rate of reaction in **(c)(iv)**. In **(d)**, the candidates did not convincingly explain how carbon dioxide contributes to climate change. A significant proportion of the candidates did not respond to many parts of this question.

(a) (i) Some candidates recognised that limestone is calcium carbonate. The commonest error was to suggest 'slaked lime'.

(ii) Candidates did not know that natural gas is mainly methane. The commonest incorrect answer was to suggest 'hydrogen'.

(b) Some candidates gained credit for knowing that carbon dioxide is a product of the thermal decomposition of calcium carbonate; others suggested carbon. A majority suggested calcium instead of calcium oxide.

(c) (i) Most candidates did not attempt this question. Those who did, drew additional apparatus instead of or in addition to a flask or other suitable container.

(ii) Most candidates did not recognise the measuring cylinder. Some wrote 'cylinder' unqualified; others suggested 'beaker'.

(iii) Incorrect answers included 'pipette', 'graduated cylinder' or 'beaker'.

(iv) Many candidates described at least one of the changes to the rate of reaction correctly. Others referred either to 'more carbon dioxide produced' or referred to the time taken for the reaction to finish instead of effect on rate.

(d) Most candidates gave vague explanations of how carbon dioxide contributes to climate change. Incorrect answers included 'damages the atmosphere' and 'flammable'.

Question 6

A significant proportion of the candidates did not respond to many parts of this question and few gained credit.

(a) The exact percentage of nitrogen in the air was not known. Some candidates gave values around 80 per cent e.g. 80 per cent or 83 per cent. Others gave the percentage of oxygen (21 per cent) rather than nitrogen.

(b) (i) Some candidates referred to the group in the Periodic Table rather than the electronic structure of argon. Others wrote about reactivity in terms of the reactivity series or tried to relate it to oils being unreactive. The latter was a confusion between argon gas and argan oil.

(ii) Candidates need more practice in learning the use of specific elements and compounds in the syllabus. Some candidates, realising that argon is unreactive, suggested 'fire retardants'.

(c) Candidates need more practice in learning the sources and adverse effects of specific pollutants. Most answers were very vague or incorrect e.g. for carbon monoxide 'effects human breathing' or for oxides of nitrogen 'trees' (unqualified).

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Question 7

A significant proportion of the candidates did not respond to many parts of this question and few gained any credit.

(a) Some candidates realised that hydrogen is formed at one of the electrodes, but it was always given at the incorrect electrode. Other errors included 'chloride' rather than chlorine and 'carbon' at one or other of the electrodes.

(b) Although some candidates chose unreactive metals such as copper or gold, none chose platinum. Others chose reactive metals such as sodium. Carbon was also chosen, despite the fact that it was in the stem of the question.

(c) (i) A majority of the candidates did not appear to know the meaning of the term 'separation' and wrote answers relating to motion e.g. 'fast'. Others referred to motion as 'diffusion' or 'smooth' rather than rapid or random.

(ii) Candidates need more practice in learning specific tests for gases. The test for oxygen was not known. Typical incorrect examples were biological and related to inability to breathe in its absence or 'putting a leaf in a tube'.

Question 8

Parts **(a)**, **(b)** and **(c)** were answered well by some candidates. Part **(e)** was answered well by nearly all the candidates. In **(b)(i)**, few candidates knew about the structure and bonding in diamond and in **(d)** most candidates thought that lithium oxide is an acidic oxide. A significant proportion of the candidates did not respond to **(b)(i)**, **(c)** and **(d)** of this question

(a) Those candidates who knew the properties of simple covalent molecules usually gained full credit. A significant proportion of candidates suggested **Q** and **S** rather than **P** and **T** but some of these seemed to guess the properties and gave one correct answer related to simple covalent compounds.

(b) (i) Few candidates were able to describe the structure and bonding in diamond. Reference to a lattice was the commonest correct answer. None of the candidates referred to covalent bonding.

(ii) Some candidates realised that diamond is very hard. Others suggested that diamond is 'dense' or 'does not corrode', which were not accepted as answers.

(iii) Some candidates named another form of carbon; graphite being the commonest correct answer.

(c) Some candidates gave one correct difference between copper and lithium; few gave two differences. Many confused the differences, suggesting that lithium 'has a high melting point' or 'copper is more reactive'. Some candidates chose malleability or ductility but did not gain credit because they suggested that transition elements were not malleable or ductile rather than less malleable or less ductile.

(d) Most candidates thought that lithium oxide is an acidic oxide.

(e) Most candidates deduced the correct order of reactivity. One error was to include the word 'metal' in one of the boxes instead of the name of the metal (copper). Candidates should be advised to distinguish the title in the table from the names of the metals.

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CHEMISTRY

Paper 0620/41
Theory (Extended)

Key messages

- When any question asks, 'State what happens to the position of equilibrium?', the only possible acceptable answers are:
  - shifts to the right
  - shifts to the left
  - no change.

  Any other references, e.g. 'to more product formed / equilibrium shifts in the endothermic direction' are ignored during marking.
- When a question asks for a molecule to be drawn showing all the atoms and all the bonds, it is not acceptable to leave out the O-H bond.
- When a question asks for the name of a substance, candidates should ensure that their answer is a name as opposed to a formula or an equation.
- Some candidates alter responses instead of rewriting them, this often makes their answer difficult or impossible to read.

Comments on specific questions

Question 1

(a) The Haber process was known by many candidates. A wide variety of spellings was seen. Nitrification and the Contact process were seen occasionally.

(b) This was answered quite well. Distillation was occasionally seen instead of fractional distillation.

(c) This was answered quite well. There were no common incorrect answers.

(d) This was answered very well. There were no common incorrect answers.

(e) Candidates found this the most difficult part of **Question 1**. Condensation polymerisation was a very popular answer. A wide variety of other answers was seen including deamination, depolymerisation, fermentation, cracking, decomposition and hydration.

(f) This was answered quite well. Distillation and fractional distillation were occasionally seen.

Question 2

Candidates usually performed well on this question. The nucleon number of chlorine was occasionally seen as either 35 or 35.5 instead of 37. For the copper ion, the number of electrons was often given as 31 rather than 27. The missing symbol was occasionally identified as Rb (proton number 37).Candidates should be aware that if a symbol for an element has two letters, as in the case of C*l* ,the second letter must be clearly seen to be lower case. This also applies in **Question 3(a)**.

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Question 3

(a) The formula of chlorine was often represented as either Cl or Cl^-. Some candidates gave the wrong formula for potassium chloride, even though KCl was given in the question.

(b) The potassium ion was often given the electron arrangement of 2,8. Those who drew the chloride ion as 2,8,8 often used 8 dots in the outer shell. It is good practice to draw electrons in pairs.

(c) (i) Candidates should make sure that they are adequately prepared for questions of the type 'State what is meant by the term...'. Candidates should be aware that the substance that is decomposed must be molten or aqueous.

(ii) Candidates should be aware that molten potassium chloride only contains the elements potassium and chlorine. Thus potassium and chlorine are the only possible products of electrolysis of molten potassium chloride. Some candidates gave equations despite being asked for names of the products. The products at the anode and cathode were occasionally reversed. Common incorrect answers included potassium ions, chloride ions, chloride (as opposed to chlorine), K^+, Cl and Cl^-.

(d) (i) Candidates performed poorly on this question. Many gave equations for the discharge of potassium ions or chloride ions.

(ii) Chloride, chloride ions, Cl or Cl^- were often seen as incorrect answers. Hydrogen was occasionally seen.

(iii) Potassium oxide and potassium chloride were seen quite often. Some candidates gave answers other than potassium compounds.

(e) This was answered very well. Multiple bonds were drawn very occasionally. It is good practice to draw electrons in pairs.

(f) (i) Many gave the correct physical state as liquid. It was unusual to see candidates referring to all three temperatures in their explanations. Many seemed to have difficulties in dealing with negative numbers. Some candidates referred to room temperature which was an irrelevancy. Candidates often referred to either melting point or boiling point instead of referring to both melting point and boiling point.

(ii) Many answers referred only to potassium chloride without any reference to chlorine. Ionic bonds between atoms or molecules or intermolecular ionic bonds were seen regularly. Weak covalent bonds in chlorine were referred to regularly and incorrectly. A statement that said the bonding in potassium chloride is weaker than the bonding in chlorine was often missing.

Question 4

(a) Candidates should make sure that they are adequately prepared for questions of the type, 'State what is meant by the term...'. The forward reaction is equal to the reverse reaction (without reference to rate) was seen often. The 'concentrations of reactants and products become equal' was another common answer.

(b) (i) Candidates found this was the most demanding question on the paper. Successful answers had to refer to nitrogen dioxide without saying more nitrogen dioxide was formed or suggesting that the equilibrium shifted. Nitrogen dioxide molecules being pushed closer together or an increase in the concentration of nitrogen dioxide due to the increased pressure were mentioned only rarely.

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(ii) The equilibrium shifts to the left because there are less molecules on the left-hand side of the equation than on the right-hand side. Those that mentioned that the pressure increased had to go on to state the significance of this. Vague statements such as 'to restore the balance / to obey Le Chatelier's principle / to oppose the change in pressure / the backwards reaction has less molecules' were all common.

(c) (i) Responses that attempted to answer the question without referring to the position of equilibrium were extremely common.

(ii) There was a great deal of confusion between equilibrium and rates of reaction. The rates of **all** chemical reactions (with the exception of reactions that are catalysed by enzymes) increase as the temperature increases. Thus the rates of both forward and backward reactions increase in this case. Candidates were usually reluctant to give the same answer to both parts of the question.

Question 5

(a) Many candidates mixed the two solids together without dissolving them in water first. Descriptions of separation or filtering the sodium ions from the iodide ions and the lead ions from nitrate ions and then mixing the iodide and lead ions together or other similar statements were seen. Washing the residue after filtration was often mentioned without reference to water being used for the washing.

Equations were often unbalanced or contained incorrect formulae such as PbI (despite PbI_2 being given in the stem).The formula of sodium nitrate was often written with unnecessary brackets as $Na(NO_3)$. Equations should be written on one line.

Unnecessary work on the filtrate, including descriptions of crystallisation, was occasionally described.

(b) (i) Candidates found this challenging. Burning splints relighting was a common answer.

(ii) Candidates performed very badly on this question. Candidates seemed unaware that the **2** at the beginning of **2**$Zn(NO_3)_2.6H_2O$ multiplies everything in the formula that follows it. The **2**ZnO was commonly seen. **4**NO_2 was less common. Unfortunately, **6**H_2O was very common. **12**H_2O was only seen extremely rarely.

(c) (i) Candidates were largely unaware of the practical technique required to ensure that all the water had been removed. The hydrated salt should be:

- weighed
- heated
- cooled
- reweighed.

These steps should be repeated until there is no loss in mass i.e. the mass becomes constant. This indicates that all the water of crystallisation has been given off.

Qualitative techniques, such as those involving copper(II) sulfate or cobalt(II) chloride, do not detect very small quantities of water which may still be present in the crystals. Similarly, no apparent change in the appearance of the crystals is not a guarantee that a small amount of water is no longer present.

(ii) Many candidates calculated the first three values correctly but were unable to determine the value of ***x*** from the moles of H_2O and the moles of Na_2SO_4.

Question 6

(a) (i) This was answered quite well. Bauxite and iron oxide were seen occasionally.

(ii) Oxygen was commonly seen instead of, or as well as, air. It is unnecessary to use oxygen, which is much more expensive.

(iii) Slag was often spelt incorrectly and led to a loss of meaning e.g. 'slug'. Carbon dioxide was a common incorrect answer.

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(iv) Some candidates seemed to confuse this with the use of cryolite in the extraction of aluminium and stated, 'lowering the operating temperature' as the answer. 'Removing impurities' and 'catalyst' were seen very often.

(b) The symbol for sulfur had to be included in the answer. Some candidates gave numbers without a symbol as their answer. Others gave answers without a charge. Iron with a negative charge was seen occasionally. S^{2-} and $2S^{-}$ were both fairly common answers.

(c) (i) This was answered very well. There were no common errors. An extremely small number gave answers that were not on the list.

(ii) This was answered very well. There were no common errors. An extremely small number gave answers that were not on the list.

(d) (i) The majority of candidates wrote that magnesium is more reactive than iron. Further explanation often included the phrase 'sacrificial protection' without explaining its meaning. Magnesium rusting instead of iron was another incorrect answer. 'Magnesium forms a coating that acts as a barrier', was another false statement that was seen often.

(ii) **'**Copper is less reactive than magnesium', is an irrelevant statement that was regularly seen. 'Copper is unreactive', without a comparison to iron, was also common.

Question 7

(a) There were some excellent answers to this question in which all steps of the working were clearly shown. Common errors included:

- dividing all three percentages by the lowest one, i.e. 8.11
- approximating the number of moles of carbon atoms from 1.5 to either 1 or 2
- attempting to multiply 1.5, 3 and 1 by two and achieving incorrect values
- dividing the percentages by the relative atomic masses and achieving the correct values of 4.05, 8.11 and 2.70. These were then approximated to 4, 8 and 3 (or 2), which gave rise to an incorrect empirical formula.

(b) Many gave numerical answers instead of chemical formulae. Some formulae had extremely large numbers of atoms. These molecules had relative molecular masses much larger than 32.

(c) (i) This was answered reasonably well. $C_nH_{2n}O$ / $C_nH_{2n}O_n$ / $C_nH_{2n} + O_2$ were common incorrect answers.

(ii) The O-H bond was often missing. Many molecules were drawn in which carbon, hydrogen and oxygen had numbers of bonds, which were different to the required numbers of 4, 1 and 2 respectively. Aldehyde groups(CHO) were occasionally drawn. Propanoic acid was occasionally seen instead of butanoic acid.

(iii) The spelling of homologous was sometimes incorrect. Carboxylic acid was occasionally seen, as were isomers and isotopes.

(d) (i) This was answered reasonably well. The correct colours were very occasionally written the wrong way round.

(ii) Many candidates chose to omit propene from their answer. Others ignored the requirement for a 1:2 molar ratio of products.

(iii) 'Additional' was often seen instead of addition. Condensation was occasionally seen.

(iv) Butane was commonly drawn. Poly(ethene) was the polymer that was drawn most commonly. Some products contained oxygen atoms. Very few answers contained CH_3 groups. Hydrogen atoms were often seen at both ends resulting in the formation of a small molecule as opposed to a polymer. A bracket was occasionally drawn around three carbon atoms as an attempt to represent propene.

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CHEMISTRY

Paper 0620/42
Theory (Extended)

Key messages

- If a symbol or formula of a chemical is asked for, a name will not gain credit. This was the case in **Question 2(b)** where the formula of the acid was asked for. Candidates who wrote 'nitric acid' received no credit as they were not addressing the question.
- If the name of an organic compound is asked for, credit will only be given for a correct name as this shows understanding of the prefix and of the suffix of organic nomenclature
- Where candidates are required to select an answer from a set of possible choices, such as **Question 1**, then candidates should be encouraged to make sensible guesses rather than leaving an answer blank. There is no penalty for an incorrect attempt.

General comments

All marks were accessible to candidates and there appeared to be sufficient time for all questions to be answered.

The calculation questions were generally well done but many candidates found **Question 4**, involving electrolysis, and **Question 6**, involving organic chemistry, challenging.

Candidates must be prepared to do calculations using the mole concept.

Comments on specific questions

Question 1

Candidates performed well on this question, requiring choices from the eight Period 3 elements given in the question. Parts **(a)**, **(b)** and **(c)** were almost universally correct.

Parts **(h)**, **(i)** and **(j)** proved to be the hardest with less than two-thirds of the candidates getting these questions correct.

A common incorrect answer to **(j)** was **S**, which suggested that weaker candidates may have been unfamiliar with the term 'binary compound'.

Question 2

(a) (i) Most candidates knew that 'isotopes' was the name given to atoms of an element with different nucleon numbers, although 'isomers' was occasionally seen.

(ii) The numbers of sub-atomic particles were well known. Common errors were to either give each isotope the same number of neutrons or to give the Ag^+ ion one more electron than the Ag atom.

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(iii) This question, asking for the definition of relative atomic mass, was written in an unusual manner. Instead of generating their own wording candidates had to fill in blanks. Candidates did not perform well with only a relatively small proportion gaining full credit.

Most candidates knew that relative atomic mass is an 'average' mass of naturally occurring atoms. The least well-known answer was that the scale is based upon a 'carbon-12' atom with just 'carbon' being the most frequent incorrect answer. Slightly more knew that the mass of this atom was '12.0' units. Wild guesses included '6×10^{23}' and '1 mole'

(iv) The understanding of the definition that relative atomic mass is the average mass of isotopes, was tested in this question. Candidates were expected to realise that if there were two isotopes, one weighing 107 and the other weighing 109, then if the relative atomic mass was 108.0, each isotope was present as 50 per cent of the atoms. A common error was to express $\frac{107}{108}$ as a percentage.

(b) Candidates need to be reminded that if a formula is asked for, the response 'nitric acid' will gain no credit. Candidates generally knew the answer, although H_2NO_3 was a common error. Some candidates attempted to write equations to show silver oxide reacting with nitric acid.

(c) (i) Relatively few candidates wrote 'yellow precipitate'. The commonest error was to describe it as a white precipitate.

(ii) A large number of candidates wrote full equations or left spectator ions in their answer.

(d) Most candidates knew ammonia was the name of the gas produced from a nitrate within an alkaline solution, but a far lower proportion knew that aluminium was needed in order to generate ammonia.

(e) The term 'photochemical' was well known by better performing candidates. A frequent error was to use the term 'photosynthesis'.

(f) (i) Many candidates misinterpreted what was required and wrote the name of a homologous series rather than the name of a member of the homologous series.

(ii) The question was designed to test if candidates knew the names of the products of a substitution reaction. The expected answer of 'chloro' used as a prefix to the named alkane was frequently seen.

Many candidates assumed HCl was 'hydrochloric acid', rather than the correct term 'hydrogen chloride'. Candidates need to be told that HCl when generated in organic reactions is hydrogen chloride and, due to the absence of water, is not hydrochloric acid.

Question 3

(a) It was expected that the full term, 'thermal decomposition', would be used to describe the action of heat on sodium hydrogencarbonate.

(b) Although many of the better performing candidates successfully gained full credit, candidates struggled with the mole concept. Many candidates did not read the question correctly. The first part of the question wanted the mass of one mole of sodium hydrogencarbonate, whereas many divided the mass of sodium hydrogencarbonate, (12.6 g) by its molar mass (84 g) to give an incorrect answer of 0.15.

(c) Most candidates knew the formula for calcium hydroxide, slightly fewer scored the second mark, with many thinking the precipitate was CaO.

Question 4

(a) The term electrolyte was known by most candidates. Some candidates misinterpreted the question and gave a familiar example of an electrolyte.

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(b) (i) Candidates were asked to complete an ionic half-equation, which was partially written. It was expected that candidates would firstly balance charges by inserting '4' before OH^- and would balance atoms by using $2H_2O$ as the missing product. Many candidates were unable to balance the atoms.

(ii) Most candidates picked up that the presence of four electrons on the product side meant OH^- ions had lost electrons.

(c) Most candidates correctly suggested effervescence would be seen. No credit was awarded for 'gas given off' or 'gas formed' as this is a conclusion made by observing the effervescence which takes place.

(d) The ionic half-equation for the cathode reaction was known by many. Candidates need to be aware that although $2H^+ + 2e^- \rightarrow H_2$ may be considered mathematically equivalent to $2H^+ \rightarrow H_2 - 2e^-$, the latter is not a correct chemical description of the changes taking place.

(e) (i) Most candidates knew that concentrated aqueous sodium chloride produced the same cathodic product as dilute aqueous sodium chloride and wrote effervescence or fizzing. Weaker responses suggested that sodium would be formed within this aqueous system.

Candidates had been told earlier in the question that oxygen is produced at the anode during electrolysis of dilute aqueous sodium chloride so 'effervescence' was not accepted as a suitable answer. Better performing candidates were able to state that a green gas was seen.

(ii) Most candidates correctly stated a blue colour for the litmus, correctly explaining that an alkaline solution of sodium hydroxide was left.

(f) This question proved to be difficult. Graphite was a common incorrect response and some opted for a metal far lower than hydrogen in the reactivity series such as silver, gold or platinum.

Question 5

(a) (i) The key to this equation was to realise that nitrogen was diatomic. Hence the balancing followed on from this. Candidates who performed less well tended to make a variety of errors, which showed a misunderstanding of equations.

(ii) The electronic structure of the nitride ion was well attempted. Only a small number omitted the extra three electrons needed to make up an octet.

The octet should be made up of five crosses (nitrogen electrons) and three dots representing electrons from lithium.

(b) (i) In general, candidates were confident in performing the two calculations involving bond energies and the answers 1425 kJ and 1800 kJ were frequently seen. However, a significant minority did not realise that the net energy change was found by subtracting 1800 from 1425 to give –375 kJ/mol. Doing the reverse subtraction to give +375 kJ/mol was a common error.

(ii) The current syllabus does not require candidates to know that a negative sign equates to an exothermic change, but many did know this. Candidates were expected to realise that the reaction was exothermic because the energy needed to break bonds was less than the energy released when bonds are formed.

Many candidates used incorrect phraseology, which suggested that bond formation required energy. A typical example of this would be, 'energy used to break bonds is less than the energy to used to make bonds' implying, incorrectly, energy was taken in to make bonds.

(iii) Many perfect answers were seen. The most frequent error was the omission of the non-bonding electrons on the fluorine atoms.

Most candidates pair non-bonding electrons. This is good practice as it is easier to check that atoms have a full outer shell. Candidates who opted to draw individual electrons often did not allocate the full eight electrons to fluorine atoms.

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(c) The three key marking points were:

- lithium fluoride has attraction between **ions**
- lithium nitride has attraction between **molecules**
- the attraction between ions is stronger than attraction between molecules.

Many candidates stated LiF has attraction between ions and Li_3N has attraction between molecules and the intermolecular forces in LiF are weaker than the intermolecular forces in Li_3N thus stating LiF is molecular, which contradicted their earlier statement.

(d) (i) This calculation was completed correctly by most of the candidates. Where candidates did not derive 35 per cent as an answer the working was looked at. Many candidates left the relative formula mass calculation of ammonium nitrate (NH_4NO_3) as $14 + 4 \times 1 + 14 + 16 \times 3$ without providing a value for the relative formula mass.

(ii) Most candidates correctly stated ammonium nitrate is a fertiliser when used in agriculture. Vague responses such as 'to help plants grow' were not credited, neither were statements about changing the acidity of soils.

(iii) Better performing candidates demonstrated their knowledge of the syllabus. Others resorted to guesses, frequently suggesting mineral acids would displace ammonia from an ammonium salt.

(e) (i) The syllabus definition of a base as a proton acceptor was well known.

(ii) Most candidates were aware that ammonia was a weak alkali and gave a suitable pH value within the accepted range of above pH 7 up to pH 11.

Candidates who wrote 'above pH 7' were not given credit as, for example, pH 14, which although above pH 7, would not be a weak alkali.

Question 6

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

(ii) This was a challenging question about polymerisation. Candidates were asked to draw part of the polymer structure formed from two molecules of **A** and two molecules of **B**. They were asked to draw all the atoms and bonds in the linkages. Thus three 'inter-block' ester links were needed and the orientation of each ester link needed to match the shading of the 'blocks'. Being part of a polymer, continuation bonds were expected. Common errors were to omit the fully displayed structures of the linkages; incorrect orientation of the linkages; omission of continuation bonds.

Candidates need to consider the valencies of the atoms drawn; trivalent oxygen and carbon atoms were commonly seen in the linkages drawn.

(iii) Most candidates knew water was the other product in this condensation polymerisation.

(b) (i) The structure of the linkage in complex carbohydrates was poorly attempted.

(ii) The two sets of conditions were generally not known. The term 'enzyme' was seen more often than acid amongst those who did gain credit.

(iii) The use of chromatography in identifying individual sugars was not well known.

(c) (i) Most candidates knew that fermentation was the process which produced ethanol from glucose.

(ii) The equation for fermentation was less well known. Many candidates gave the products as $CO_2 + H_2O$, suggesting a possible confusion with respiration. A significant proportion of candidates gave C_2H_5OH as a product (C_2H_6O was also accepted) but incorrectly 'balanced' the equation by giving $C_4H_6O_5$ as the other product.

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CHEMISTRY

Paper 0620/43
Theory (Extended)

Key messages

- When drawing organic structures, candidates should be aware that structures will require all bonds to be drawn and thus the valency of atoms used needs to be correct. Trivalent and pentavalent carbon atoms, divalent hydrogen atoms and/or monovalent oxygen atoms were seen in **Question 7(c)(iii)**. In **Question 7(c)(iv)**, the O-H bond was often omitted within the carboxylic acid group.
- Candidates who performed less well had not learnt the definitions and statements within the syllabus. This was seen in **Question 3(c)(i)**, which asked for the meaning of the term electrolysis; **Question 4(a)**, which asked for the meaning of the term equilibrium and **Question 7(c)(i)** which asked for the name given to compounds with the same molecular formula but different structures.
- Some candidates need more familiarity with answering questions based on the practical procedures of salt preparation.

General comments

The vast majority of the candidates completed the entire paper in the allocated time, although it was not uncommon for candidates not to attempt some parts of the paper.

Candidates who read the questions carefully and had prepared for the examination thoroughly, produced some excellent answers that were well structured and detailed.

Very few candidates felt the need to write on extra pages. If extra pages are used, the questions must be clearly numbered.

Comments on specific questions

Question 1

Candidates found it challenging to identify the names of the required processes correctly. Part **(g)** and **(b)** were most commonly correct, whereas **(f)** was rarely known.

(a) Polymerisation was generally known by candidates.

(b) This was generally well answered although ‘condensation’ was a common incorrect answer.

(c) This was well known by candidates although ‘anaerobic respiration’ was a commonly seen answer, which was ignored.

(d)(e) and **(g)**
These questions were well answered.

(f) The use of chromatography to separate the products of hydrolysis was only suggested by a small minority of candidates.

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Question 2

The majority of candidates were able to state the number of protons and neutrons for the boron atom. However, many were unable to link the charge on the ion with the number of electrons, which resulted in errors in both the second and third rows in the table. When representing their formula, candidates are advised to follow the format given in the question when stating the atomic number and relative atomic mass. Mg was a common incorrect symbol due to 24 protons being misinterpreted as the relative atomic mass of the particle.

Question 3

(a) When a chemical equation is asked for, this means a balanced symbol equation using correct symbols/formulae not a word equation. A very common error was not to show fluorine as diatomic. Candidates also need to be aware of the importance of using a correct uppercase letter 'N' in their sodium symbol rather than simply a large lowercase letter 'n'.

(b) Many candidates drew the electronic structure of the atoms rather than the ions. Sodium was also likely to be missing its second shell with one electron drawn in the outer shell. Some candidates had the correct idea for the electronic structures but did not recognise the importance of following the guidance given in the diagrams, which showed it was necessary to use crosses for sodium and dots for fluorine. The ionic charges were usually correct, although the answer was often seen reversed with Na^- and F^+.

(c) (i) It was clear that many of those who tried to explain electrolysis did not appreciate that it is a decomposition process whereby a molten or aqueous ionic compound is broken down using electricity. Common errors included omitting the physical state, suggesting 'separation' (a physical change) was occurring or stating the compound was broken down using a 'current' rather than specifying an 'electric current'.

(ii) Candidates were often unaware of the potential for different products when electrolysis was performed on the same ionic compound in different physical states. It was not uncommon for the same products to be suggested in both **(c)(ii)** and **(d)(i)**.

(d) (i) 'Fluoride' rather than elemental fluorine was a common error for the product at the anode.

(ii) Although the question guidance stated the cathode was the negative electrode, this did not seem to assist candidates in recognising that a positive ion must be being discharged. Errors included equations representing fluoride ion discharge, or the oxidation of sodium atoms to sodium ions.

(e) Generally this was well answered. Candidates who performed less well were able to draw a correct shared pair of electrons but omitted the non-bonding outer electrons. Candidates are advised to draw the outer shell electrons in pairs as this helps reduce the likelihood of miscounting.

(f) (i) Answers describing a change of state, such as 'melting', were common errors rather than stating the physical state of fluorine at the specified temperature.

Candidates should be reminded to follow the question guidance. For this answer they were required to refer to the data to explain their answer. Many candidates simply restated the data. For example, statements such as 'at –188 °C it has boiled and at –220 °C it has melted so at –195 °C it is a liquid'. Many candidates also believed that –195 °C was a higher temperature than –188 °C.

(ii) Rambling responses were common and often resulted in contradicting statements, such as 'ionic compounds are comprised of atoms or have molecules/intermolecular forces'. Better responses were succinct, accurate in their use of terminology, such as 'ionic bonds and attraction between molecules', and used comparative language. When two substances are being compared it is also important that candidates identify the substance they are describing. The use of non-specific terms such as 'it' or 'they' should be avoided.

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Question 4

Candidates found the question on equilibria demanding.

(a) Many candidates only offered the idea of an equilibrium being a 'reversible reaction' or a vague idea of 'balance' but did not write anything to acquire credit. Examples of loose wording include 'forward reaction equals backward reaction' (no mention of rate) and 'concentrations of reactants and products are the same', when what should have been written was 'concentrations of reactants and products remain the same' or 'concentrations of reactants and products remain constant'.

(b) (i) Candidates should be familiar with questions that ask for an explanation of the position of equilibrium following a change in conditions. Incorrect answers often identified the cause as due to the temperature remaining constant or that the syringe was sealed, rather than recognising that the equilibrium position remaining constant was due to the number of moles of gas on each side of the equilibrium being the same.

(ii) Many candidates had the correct idea about concentration being increased but did not specify for iodine, or wrote about iodine being closer together but omitted 'particles' or 'molecules' from their answer. Descriptions of rate change and equilibrium movement were also common incorrect answers.

(c) (i) The candidates' wording was not always easy to understand and sometimes contradictory, for example 'equilibrium shifts towards the reactants' followed by 'forming more iodine and hydrogen'. Candidates are advised to focus their descriptions of changes in equilibrium position as 'shifting to the left' or 'shifting to the right' or 'staying the same'. Candidates should be aware that there is no such thing as an 'exothermic side' to a reaction; there is, however, an exothermic direction.

(ii) Most candidates were able to gain partial credit. Weaker responses continued to discuss movement of the equilibrium position rather than focus on the temperature effect on rate.

Question 5

(a) Only a minority of candidates performed well on this question. 'Add excess zinc carbonate' was a common vague statement with only a small minority describing the relevant observation, such as 'until bubbles stop forming' or 'solid remains in the beaker'. The filtering stage of the process was often omitted, with candidates moving straight from mixing reagents to heating. Many attempted the chemical equation.

(b) (i) The test for sulfur dioxide was not well known. It is worth reminding candidates that correct oxidation states are required when identifying chemical reagents.

(ii) Few candidates gained full credit. In the hydrated salt, the waters of crystallisation and the iron(II) sulfate were often treated as being disconnected from each other, hence leading to an incorrect answer of $7H_2O$ on the right-hand side.

(c) (i) As with the practical description in **(a)**, this method did not appear to be familiar to candidates despite the question describing the steps involved. The majority described a test for the water evolved, which was not asked for in this question.

(ii) Candidates were able to determine the mass of water given off but were unable to translate this into a number of moles.

Question 6

Many candidates found this question challenging and demonstrated limited knowledge of this industrial process.

(a) (i) There was a very wide variety of incorrect answers suggested with 'water' the most frequently seen answer.

(ii) Iron was not often identified as the substance leaving the blast furnace at **A**.

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(iii) 'Carbon dioxide' was a common incorrect answer.

(iv) A common error was giving two answers, only one of which was correct, for example 'iron and oxygen' or 'carbon and coke'. Air, carbon monoxide and carbon dioxide were common incorrect answers.

(v) Few candidates gained full credit. Although carbon dioxide was correctly identified by many candidates, nitrogen was rarely suggested as a waste gas. Alternative incorrect answers included carbon monoxide, oxygen and hydrogen.

(b)(i) Better performing candidates knew that zinc sulfide was the main compound present in zinc blende.

(ii) This question was answered well.

(c) 'Tin' and 'bronze' and other alternative combinations such as 'copper zinc' were commonly seen incorrect answers.

(d)(i)(ii) This question was made more accessible due to the provision of a list of copper's properties. However, despite this guidance some candidates made alternative incorrect suggestions. Awareness of the similarities and differences in properties between the alkali metals and transition metals was not well known.

Question 7

The understanding of empirical and molecular formulae is an aspect many candidates find difficult.

(a) Some candidates omitted the first step and divided each percentage by 11.63 instead of using the A_r of each element. Other candidates gave a numerical final answer rather than applying their ratio to determine a formula.

(b) Candidates who did not understand the meaning of the term 'empirical formula' made no attempt to answer this question. A numerical answer was sometimes seen rather than a molecular formula due to candidates not multiplying the empirical formula by a factor of two.

(c)(i) This answer was well known, although some candidates demonstrated confusion with the term 'isotopes'.

(ii) 'Alcohols' and 'esters' were commonly suggested incorrect answers.

(iii) Candidates were often more successful at naming a suitable ester than they were at drawing a correct structure. Many candidates attempted the structure of a three carbon-based organic compound however, pentavalent C atoms, trivalent O atoms and divalent H atoms were commonly seen.

(iv) Candidates were more often successful at correctly identifying the name of **V** as propanoic acid than at correctly drawing its structure. As in **(iii)**, incorrect valencies for carbon, oxygen and hydrogen were commonly seen. The requirement for all bonds to be shown meant that credit for the diagram was not awarded for those candidates who gave –OH in an otherwise correctly drawn structure.

(d) The majority of candidates were not able to identify the types of chemical reactions occurring, with 'combustion' commonly suggested for **step 1**. Many candidates did not attempt either equation. Correct equations were rare, with the cracking of decane to form either ethane plus octane or five moles of ethane plus hydrogen the most commonly seen correct answers.

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Paper 0620/51
Practical Test 51

Key messages

- There was no evidence of candidates running out of time in this practical examination.
- The vast majority of candidates successfully attempted all of the questions. The full range of marks was seen. The paper discriminated successfully between candidates of different abilities but was accessible to all. Almost all centres were able to gain the expected results in **Question 1** and **Question 2**.
- Candidates found the last question, **Question 3**, demanding.
- All centres submitted Supervisor's results as required.

General comments

The planning question (**Question 3**) needs to be carefully read so that time is not wasted with irrelevant planning to prepare materials which are provided.

Plotted points on a grid should be clearly visible e.g. crosses. Straight line graphs should be drawn with a ruler and labelled as required.

Observations are those which you can see. For example, 'fizzing, bubbles or effervescence' are observations, 'a gas or carbon dioxide was given off' is not.

Lists of answers with correct and incorrect responses are marked according to a list principle and are penalised if contradictory. For example, if the correct answer is 'precipitate dissolves/is soluble' and a candidate writes 'precipitate dissolves and a white solid forms', no credit can be awarded.

Comments on specific questions

Question 1

(a) The table of results was often completed correctly. A common error was not giving the temperatures and temperature changes to a consistent number of decimal places.

(b) Most plotted the points correctly but often not clearly. A common error was to plot the point for 5 g at 4 g. Some excellent graphs were seen. Most candidates chose a sensible scale for the *y*-axis of each 2 cm square being either 1 °C or 2 °C and were then able to plot the six points correctly. Some candidates did not follow the instruction regarding the lines having to be straight and for the right-hand line to be horizontal.

(c) (i) A significant number of candidates did not show clearly on the grid how they worked out their answer and/or missed out the units.

(ii) Better performing candidates realised that the acid had become the limiting factor and that excess sodium hydrogencarbonate was present. Vague answers such as 'the reaction finished/stopped' were common and received no credit.

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(d) Candidates found this a demanding question. If the acid used had half of the original concentration, then all the acid would have been reacted with just half of the mass of sodium hydrogencarbonate as compared to the original investigation. If half the mass of sodium hydrogencarbonate reacts then the temperature decrease would be half the original decrease. Very few correct answers were seen. Some candidates realised that the mass of sodium hydrogencarbonate required would be half the original mass.

(e) Many candidates stated that a burette or pipette would be more accurate than a measuring cylinder. Fewer candidates realised that insulation would reduce heat gain from the surroundings. A common error was to suggest stirring with something other than a thermometer or to suggest repeating the experiment and finding a mean. The latter was not acceptable as the question specifically asked for a change to the apparatus.

Question 2

Solid **E** was aluminium ammonium sulfate. Solution **F** was aqueous sodium hydroxide.

(a) Some detailed observations were seen. The formation of condensation and the solid becoming liquid/melting were the two acceptable observations that were most commonly seen. References to bubbles and fizzing were ignored.

(b) The expected observation was 'white precipitate formed'. The term precipitate was required and statements such as cloudy were not sufficient. Some answers referred to no reaction.

(c) The expected observation was 'white precipitate formed'.

(d) Formation of a white precipitate was often described but only the best responses recorded that the precipitate was soluble in excess sodium hydroxide. Some candidates reported impossible colours such as blue or purple, which could only be the result of using the wrong reactants or contaminated test-tubes.

(e) Most candidates correctly reported a positive test for ammonia with litmus paper turning blue.

(f) Some candidates had difficulty in identifying three ions. A common error was to identify the ammonia given off in **(e)** rather than naming the ammonium ion from which it was formed. Some responses confused ammonia with the nitrate ion.

(g) Many correct flame test colours were seen, although it was evident from some candidate's answers, e.g. lighted splint pops, that they were not clear what a flame test was.

(h) (i) While most candidates gave an acceptable colour for the mixing of universal indicator with an alkali, some seemed not to have used universal indicator as they widely reported other unacceptable colours.

(ii) The expected observation was 'blue precipitate formed'.

(iii) The identity of solution **F** as a copper compound was common despite the fact that copper(II) sulfate had been added to solution **F** in **(h)(ii)**.

Question 3

A number of candidates unnecessarily spent time explaining, often in detail, how to collect the volume of gas produced using a gas syringe despite the information given in the stem of the question.

The candidates were told they had to use the information shown in the diagram. This meant that the plans had to be based on the mass lost during the reaction.

The most common methods used were to measure the mass lost in a specified time or to measure the time taken until the mass of the flask and contents stopped changing.

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Some candidates opted to measure the mass lost when the mass stopped changing without measuring the time. This last method could not gain full credit as the final mass lost will be the same whatever the rate of reaction, as was the case for using methods that were not based on the loss in mass.

In order to produce valid results, each run at a different temperature should have the same mass of calcium carbonate and the same volume of acid.

It should be noted that ‘amount’ is not an acceptable term for mass or volume. As the independent variable is the temperature of the acid, experiments must be conducted using acid at different temperatures. However, the acid should not be heated so that its temperature is changing while it is reacting.

In all methods, timing is necessary and so an instruction as to when a timer is started was expected. Once a final measurement has been made, (be that mass lost in a set time or the time taken to stop reacting or lose a set mass), then there should have been an explanation of how the differences in that measured quantity relate to the rate of the reaction.

A minority of candidates did not attempt the question.

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Paper 0620/52
Practical Test 52

Key messages

- Where, in a quantitative task, a reagent is added dropwise and then in excess, candidates should give observations for the dropwise addition and for the addition in excess; making it clear which observation is for dropwise addition and which for addition in excess.
- When plotting graphs, candidates should use a cross (X) or an encircled dot (⊙) to indicate a data point; 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, then 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 as you cannot see that the gas is hydrogen. If combining two aqueous solutions produces a cloudy product this indicates a precipitate has been formed and the observations recorded should state 'a precipitate has been formed', along with the colour of that precipitate.
- Candidates should ensure they make use of the 'Notes for use in qualitative analysis' printed at the end of the question paper.

General comments

The paper discriminated successfully between candidates of different abilities but was accessible to all. The paper was generally well answered, although it appeared that some candidates had limited practical experience.

It is essential that centres use the test reagents specified in the Confidential Instructions and that a set of Supervisor results for both **Question 1** and **Question 2** are submitted. Quantitative and some qualitative tests will not give the expected results if the solutions used are of an incorrect concentration.

Comments on specific questions

Question 1

(a) Almost all candidates recorded results for five experiments and were able to record correct values for the volumes of hydrochloric acid. The volume of gas collected in each experiment should have decreased from Experiment 1 to Experiment 5. However, some candidates obtained results that did not follow this pattern or obtained gas volumes that were much lower than expected. This is probably a result of delays in inserting the bung or the bung not being properly inserted, both of which would result in the loss of gas. When recording results, all measurements made using similar apparatus should be recorded to a consistent number of decimal places. Some gas volumes were given to one decimal place and others to none. Two decimal places for volumes measured with a measuring cylinder were considered to be inappropriate.

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(b) Graph work was excellent. Most candidates used a scale of 10 cm^3 per 2 cm or 20 cm^3 per 2 cm and plotted the points correctly. Many good straight lines of best fit were seen but some candidates drew a curve or forced their straight line to go through the bottom left-hand corner of the grid, so forcing the volume of gas collected to be 0 cm^3 when the volume of acid was 4 cm^3. A small number of candidates chose unsuitable scales, this caused difficulty in both plotting and reading the graph. 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 units of the variable – this is indicated in the mathematical requirements in the syllabus and by the Association for Science Education (A.S.E.).

(c) (i) This question was well answered, with most candidates showing their working on the grid.

(ii) Nearly everyone got the correct answer by dividing their answer to **(c)(i)** by 7**.** A few showed rounding errors or ignored the equation they were given on the question paper.

(d) (i) Almost all candidates realised that the gas made would be lost if the bung was not replaced very quickly.

(ii) Some excellent answers were seen to this challenging question. The most commonly seen fully correct solution was to attach the sodium carbonate to a thread that passed down the side of the bung and then either pulling the thread or tipping the tube to start the reaction. Some candidates added the acid using a burette or separating funnel passing through a second hole in the bung; this method did not receive full credit as it would result in air being displaced from the tube into the measuring cylinder and so would give incorrect readings for the volume of gas. Common answers that received no credit were to just change the method of gas collection (which will not solve the problem of gas loss when the bung is removed) or to make another hole in the tube through which the sodium carbonate is added (this will not solve the problem caused by removal of the bung).

(e) Almost all candidates could correctly state that a burette gave more accurate volumes than a measuring cylinder.

(f) Some excellent sketch lines were seen. Better performing candidates realised that if the acid concentration was halved then the volume of gas collected would also be halved and produced sketch lines where the volume of gas was half the volume collected in the initial experiments. Partial credit was available to those candidates who realised the gas volume would be less but did not show a reduction by 50 per cent. It should be noted that candidates should not plot points for sketch lines. Some candidates ignored the instruction to draw their sketch line on the grid and instead chose to draw another grid in the space under the question. This made comparing the two lines difficult.

Question 2

(a) The majority of candidates were able to correctly report the formation of a white precipitate. However, some candidates stated incorrectly that the ‘precipitate redissolved’ or that there was ‘effervescence’.

(b) Almost all candidates correctly reported the formation of a precipitate. Those candidates who reported an incorrect colour were not awarded credit, but an error carried forward was applied in **(e)**.

(c) All of the observations noted on the mark scheme were seen in candidates’ answers. The most commonly seen observation was the colour change. Many candidates observed the effervescence; a significant number did not. The gas test caused the greatest difficulty and some candidates gave impossible results. The most common of which being that the gas produced turned limewater milky (as there was no carbon in either of the reagents, carbon dioxide simply could not be formed). The volume and concentration of hydrogen peroxide specified could have produced up to 300 cm^3 of oxygen, which should have been ample to test.

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(d) Those candidates who gave a correct positive gas test result in **(c)** almost always gave the correct identity for the gas. Some candidates made the error of thinking that the small 'pop' often heard in a positive test for oxygen using a glowing splint meant the gas was hydrogen – it was not, this small pop is probably caused by decomposition products from the wood igniting. The test for hydrogen involves using a lighted, not a glowing, splint.

(e) Almost all candidates who had made correct observations correctly identified **G** as calcium iodide. Candidates are advised to use the names when identifying compounds, as if a formula is given then it must be the correct formula.

(f) While many correct flame test colours were seen, it was evident that a small minority of candidates are not aware of what a flame test is, giving answers such as 'squeaky pop' or 'fizzing', which have no connection with a flame test.

(g) This was well answered by the majority of candidates and many answers were well set out and the sequence of changes was clear. A few candidates stated that the precipitate formed did not redissolve, which may be due to the aqueous ammonia used being of a much lower concentration than that specified in the Confidential Instructions. Some candidates gave contradictory answers, such as 'blue precipitate dissolved to give a dark blue precipitate' and so could not gain full credit, if the precipitate dissolved it could not still be a precipitate

(h) This was a more difficult observation as the white of the precipitate is slightly masked by the blue of the solution. Despite this, the majority of candidates correctly noted the formation of a white precipitate.

(i) Most candidates correctly reported mixing the two reagents resulted in a brown colour.

(j) The vast majority of candidates correctly identified **H**. The most common error was to give the identity as a chloride rather than a sulfate, presumably due to mistaking the test in **(h)** as the halide ion test rather than the sulfate ion test.

Question 3

Candidates were required to plan an investigation to calculate experimentally the percentage of water in epsomite (hydrated magnesium sulfate). The method used by the majority was to remove the water by heating the solid strongly, although a minority successfully condensed and weighed the water.

With the mass loss method, most knew to weigh before and after heating the sample and went on to describe how the results should be used. The missing details were commonly a suitable vessel for strongly heating, such as a crucible, and the idea of heating to constant mass. Apparatus such as test-tube (rather than a crucible) were not considered as suitable because the water that is evaporated will at least partially recondense at the far end of the test-tube.

Candidates using the collection of water method often used an unsuitable container, such as a beaker. Fitting a condenser to a beaker would be challenging. However, the idea of heating until no more water was collected was seen more often.

A few included extra incorrect steps such as washing the residue before weighing.

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Paper 0620/53
Practical Test 53

Key messages

- In a quantitative task, if a reagent is added dropwise and then in excess, candidates should give observations for the dropwise addition and for the addition in excess; making it clear which observation is for dropwise addition and which for addition in excess.
- When plotting graphs, candidates should use a cross (X) or an encircled dot (⊙) to indicate a data point; 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, then the line, if drawn in pen, cannot be erased.
- Observations are those which can be seen. For example, 'fizzing' is an observation but 'hydrogen gas is produced' is not as you cannot see that the gas is hydrogen. If combining two aqueous solutions produces a cloudy product this indicates a precipitate has been formed and the observations recorded should state 'a precipitate has been formed', along with the colour of that precipitate.
- Candidates should ensure they make use of the 'Notes for use in qualitative analysis' printed at the end of the question paper.

General comments

The paper discriminated successfully between candidates of different abilities but was accessible to all. The paper was generally well answered, although **Question 3** was frequently not attempted by some candidates.

Some responses might suggest that candidates had limited practical experience. This was particularly true on **Question 2**, the Qualitative Analysis question.

It is essential that centres use the test reagents specified in the Confidential Instructions and that a set of Supervisor results for both **Question 1** and **Question 2** are submitted.

Comments on specific questions

Question 1

(a) Almost all candidates recorded results for five experiments and were able to record correct values for the volumes of sulfuric acid and water. The volume of gas collected in each experiment should have increased from experiment 1 to experiment 5. However, some candidates obtained results that did not follow this pattern or obtained gas volumes that were much lower than expected, this is probably a result of delays in inserting the bung or the bung not being properly inserted, both of which would result in the loss of gas.

(b) Many excellent graphs were seen. Some candidates made things difficult for themselves by selecting a *y*-axis scale that was difficult to use. When plotting graphs, scales should be chosen such that the plotted data takes up over half of the available space. It is recommended that each major grid line should be equivalent to 1, 2, or 5 (or those numbers multiplied by 10^n). Candidates who chose difficult scales often did not gain credit for plotting the points. Some candidates struggled to draw an acceptable curve of best fit; a line which meanders from point to point is not a curve of best fit. The expected line should have been a curve of decreasing negative gradient.

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(c) Many candidates performed well on this question. To gain credit for the extrapolation, the extrapolation had to follow on smoothly from the graph line and not take a sudden change of direction.

(d) (i) Many well set out calculations were seen. The most common errors were incorrect rounding of an otherwise correct number or an error in the units.

(ii) This was very well answered with almost all candidates selecting the experiment with the largest volume of gas collected.

(e) (i) Almost all candidates could correctly state that a pipette was more accurate than a measuring cylinder.

(ii) This proved more demanding than **(i)**, however, many correct answers were still seen. Non-credit worthy answers often focused on the difficulty of using a pipette or its fragility. Some candidates thought that the fact that a pipette could only measure a set volume of 25 cm^3 was a disadvantage, but as that is the volume required it was not a problem in this instance.

(f) The expected, and often seen, answer was 'gas syringe'. A burette was not accepted as it is not graduated all the way to the tap and so the gas volume recorded would not be accurate.

(g) The best responses explained the advantage of the modified apparatus. Many answers suggested that candidates had done less practical work that usual this year and were not familiar with the problem of gas escaping before the bung was reinserted.

Question 2

(a) Many candidates were able to report the formation of a green precipitate that dissolved in excess aqueous sodium hydroxide. A significant number of candidates reported other observations, such as fizzing or the formation of white precipitate. This suggests that the candidates had not used the correct reagents for the test.

(b) Some candidates were able to report the expected formation of a grey-green precipitate which did not redissolve; other candidates reported wholly impossible observations for the reagents that should have been used.

(c) Correct observations for the positive chloride ion test were seen frequently.

(d) This was expected to be an unfamiliar reaction for many of the candidates. Many candidates correctly reported either the formation of a precipitate or fizzing.

(e) Most candidates who had made correct observations in **(a)** were able to correctly identify the chromium(III) ion. Correct identification of the chloride ion was more common.

(f) Many correct flame test colours were seen. It was also evident that some candidates are not aware of what a flame test is, giving answers such as 'squeaky pop' or 'fizzing', which have no connection with a flame test.

(g) (i) Most candidates correctly reported the formation of bubbles. The question asked candidates to test the gas produced. When this is asked, it is expected that candidates will record the test and the result for the gas test that gave a positive result. Negative gas test results do **not** need to be recorded.

(ii) Many candidates correctly identified the gas as carbon dioxide.

(h) (i) Many candidates correctly reported that there was no visible change. A common error was to report that there had been fizzing – this is not possible when aqueous sodium hydroxide is added to a solution containing carbonate ions.

(ii) The majority of candidates reported the formation of a green or blue precipitate.

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(i) Many candidates were able to correctly identify the potassium ion from the flame test result in **(f)**. It was not uncommon for candidates to suggest the cation was copper(II), presumably due the observation made in **(h)(ii)** and forgetting that aqueous copper(II) sulfate was the test reagent they had added to solution **J.**

Question 4

The planning task involved devising an investigation to find which of three alcohols released the most energy on combustion. The expected answer involved finding the mass of fuel required to increase the temperature of a certain volume of water by a given amount or the time taken for the temperature to increase by a given amount.

A few excellent and well thought through answers were given. However, workable descriptions of a practical method were not common. Only a minority of candidates specified using a set volume of water for all three alcohols to heat and some candidates did away with the water all together and measured the temperature rise of the alcohol. Those candidates who did burn the alcohols to heat the water normally correctly stated that the more energy released by the alcohol, the greater the temperature rise of the water. However, it was common to omit the important step of measuring the starting temperature of the water, without which the temperature rise cannot be calculated.

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CHEMISTRY

Paper 0620/61
Alternative to Practical 61

Key messages

- Most candidates successfully attempted all the questions. The full range of marks was seen. The paper discriminated successfully between candidates of different abilities but was accessible to all. Candidates found the last question, **Question 4**, demanding.
- Most candidates were able to complete tables of results from readings on diagrams, as in **Question 2**.

General comments

Plotted points on a grid should be clearly visible e.g. crosses. Smooth line graphs should be curves with no straight-line sections drawn with a ruler.

Observations are those which can be seen. For example, 'fizzing' is an observation, whereas 'a gas was given off' is not. Smells, such as 'the pungent smell of ammonia' and 'bleach or swimming pool smell of chlorine', are acceptable as observations.

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.

Lists of answers with correct and incorrect responses are marked according to a list principle and are penalised if contradictory. For example, if the correct answer is 'precipitate dissolves/is soluble' and a candidate writes 'precipitate dissolves and a white solid forms', no credit can be awarded.

In the planning question, **Question 4**, there is no need to write a list of apparatus at the start of the answer; any apparatus used should be referred to in the description of the experiment so that it is clear for what purpose that apparatus has been used.

Comments on specific questions

Question 1

(a) Some candidates were either unfamiliar with the common items of laboratory apparatus or did not look carefully at what was being labelled. **B**, the tripod, was often referred to as a Bunsen Burner or a stand, which was insufficient. **C** was often named as a filter, which was again insufficient as funnel was required. **A** was often referred to as a pestle or (grinding) bowl instead of a mortar.

(b) (i) Most candidates who attempted this question gained full credit. A significant number of responses were left blank, indicating that some candidates need to read question papers carefully and not just look for dotted lines on which to write their answers. The most common errors were to draw multiple spots above the baseline and the solvent front at the end of the experiment rather than the spot on the baseline and the level of the solvent below the baseline in the beaker.

(ii) This was generally well-answered with most candidates realising that graphite is insoluble.

(c) (i) The most common answer given was 'three' with some candidates incorrectly identifying the substances as red, blue and green. Only a minority of candidates realised that as there were two spots on each chromatogram there must be just two coloured substances obtained from the berries.

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(ii) This was generally well answered but confused answers were common, with some candidates suggesting an indicator that was not in the table.

Question 2

(a) The table of results was often completed correctly when reading the thermometer diagrams or calculating the temperature changes. The most common errors were reading the fourth initial temperature as 22 °C rather than 22.5 °C or the first temperature after one minute as 19 °C rather than 19.5 °C. All readings should have been given to the same number of decimal places. Many candidates incorrectly gave readings to a mixture of zero and one decimal places.

(b) Most plotted the points correctly but often not clearly. A common error was to plot the point for 5 g at 4 g. Some candidates only read the instructions that the lines used should have been straight and extended until they met each other after they had already drawn curves.

(c) (i) A significant number of candidates did not show clearly on the grid how they worked out their answer and/or missed out the units.

(ii) Better performing candidates realised that the acid had become the limiting factor and that excess sodium hydrogencarbonate was present. Vague answers such as 'the reaction finished/stopped' were common and received no credit.

(d) Candidates found this a demanding question. If the acid used had half of the original concentration, then all the acid would have been reacted with just half of the mass of sodium hydrogencarbonate as compared to the original investigation. If half the mass of sodium hydrogencarbonate reacts then the temperature decrease would be half the original decrease. Very few correct answers were seen. Some candidates realised that the mass of sodium hydrogencarbonate required would be half the original mass.

(e) Many candidates stated that a burette or pipette would be more accurate than a measuring cylinder. Fewer candidates realised that insulation would reduce heat gain from the surroundings. A common error was to suggest stirring with something other than a thermometer or to suggest repeating the experiment and finding a mean. The latter was not acceptable as the question specifically asked for a change to the apparatus.

Question 3

(a) The majority related the observations to the fact that solid **E** must be hydrated. Weaker responses gave observations rather than a conclusion.

(b) Candidates were required to realise that the negative test result meant that solid **E** was not a halide. There was some confusion between the terms halogen and halide.

(c) Common errors were to identify the ions present as zinc, by not understanding **test 4** and nitrate, by confusing the test for ammonium ions and nitrate ions as they both produce ammonia gas. Identifying the ion as ammonia showed a lack of knowledge and understanding.

(d) The expected observation was a yellow/orange flame, but many candidates thought a precipitate would be formed or that there would be a squeaky pop. The latter response showed confusion between a flame test for cations and using a lighted splint as a gas test.

(e) (i) Most candidates gave an acceptable colour for universal indicator in an alkaline solution such as blue or purple.

(ii) A minority of candidates understood that this was the test for copper ions using aqueous sodium hydroxide forming a blue precipitate.

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Question 4

A number of candidates unnecessarily spent time explaining, often in detail, how to collect the volume of gas produced using a gas syringe despite the information given in the stem of the question.

The candidates were told they had to use the information shown in the diagram. This meant that the plans had to be based on the mass lost during the reaction.

The most common methods used were to measure the mass lost in a specified time or to measure the time taken until the mass of the flask and contents stopped changing.

Some candidates opted to measure the mass lost when the mass stopped changing without measuring the time. This last method could not gain full credit as the final mass lost will be the same whatever the rate of reaction, as was the case for using methods that were not based on the loss in mass.

In order to produce valid results, each run at a different temperature should have the same mass of calcium carbonate and the same volume of acid.

It should be noted that ‘amount’ is not an acceptable term for mass or volume. As the independent variable is the temperature of the acid, experiments must be conducted using acid at different temperatures. However, the acid should not be heated so that its temperature is changing while it is reacting.

In all methods, timing is necessary and so an instruction as to when a timer is started was expected. Once a final measurement has been made, (be that mass lost in a set time or the time taken to stop reacting or lose a set mass), then there should have been an explanation of how the differences in that measured quantity relate to the rate of the reaction.

A minority of candidates did not attempt the question.

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CHEMISTRY

Paper 0620/62
Alternative to Practical 62

Key messages

- The 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.
- **Question 4** was a planning task based on the percentage of water in hydrated magnesium sulfate. Nearly all candidates used a valid method, even if a few details were missing.
- The majority of candidates were able to complete tables of results from measuring cylinders on diagrams in **Question 2**, although some problems were caused by the fact that the measuring cylinder was inverted.
- Some responses might suggest that candidates have limited practical experience.

General comments

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 cannot be awarded.

Comments on specific questions

Question 1

(a) The two pieces of apparatus that had to be identified were well known; a glass or stirring rod and a conical flask.

(b) The process of filtration was very well known.

(c) The term 'filtrate' for the solution obtained after filtration was given by some candidates, with the rest using more general terms such as 'solution' or the name of a specific solution.

(d) Most candidates answered this question very well. Good responses realised that after filtration the residue needed washing and drying. The most common error was to assume that it was in solution and to describe the process of crystallisation

Question 2

(a) Nearly all candidates filled in the column with the volumes of hydrochloric acid correctly. Most could also read the inverted measuring cylinders correctly, although the inversion did cause problems for some. Readings should be recorded in a consistent manner in terms of decimal places.

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(b) Graph work was excellent, with many gaining full credit. The scale of 10 cm^3 per 2 cm was used by nearly all; the points were plotted correctly and a good straight line of best fit was drawn. A small number of candidates chose unsuitable scales such as 3, 6 or 7 units to each 2 cm square. This caused difficulty in both plotting and reading the graph. 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.).

(c) (i) This question was well answered, with most candidates showing their working on the grid.

(ii) Nearly everyone could get the correct answer by dividing by 7. A few showed rounding errors or chose a different point from that asked for in the question.

(d) (i) Most realised that gas would escape if the bung was not replaced very quickly.

(ii) Candidates found this a challenging question. The ideal answer was to have the sodium carbonate in a separate container in the boiling tube/flask and to shake or tilt it to start the reaction. Many suggestions involved a burette or separating funnel or syringe being added through a second hole in the bung to introduce the acid. Whilst this would prevent the escape of gas it would also affect the volume of gas recorded as air is displaced by the acid. Whilst this method was rewarded, it could not get gain full credit.

(e) Nearly everyone knew that the burette was more accurate than the measuring cylinder.

(f) Candidates were asked to sketch a second line on the grid for acid of half the original concentration. Most realised that it would be below the original and many drew it at exactly half the original values.

Question 3

(a) Oxygen was correctly identified by nearly everyone.

(b) Better responses correctly identified calcium iodide, with others often getting one of the ions, usually the iodide, correct. Magnesium was allowed instead of calcium as, although not mentioned in the syllabus, it would give the same results.

(c) Candidates found describing the changes observed when hydrated copper(II) sulfate was heated challenging. Marking was generous in descriptions of steam and condensation, although the most common correct observation was the colour change from blue to white. Candidates should remember that ‘water is formed’ is not an observation, but ‘droplets of water are formed’ is.

(d) The flame colour for copper was well known; blue-green was the expected answer. A few candidates were not familiar with a flame test.

(e) The reaction with ammonia was very straightforward because it was with a copper(II) compound. Responses involving a pale blue precipitate followed by a dark blue solution were common.

(f) The white precipitate with barium nitrate was very well known.

Question 4

Candidates were required to calculate experimentally the percentage of water in epsomite (hydrated magnesium sulfate). The method used by the majority was to remove the water by strongly heating the crystal, although a minority successfully condensed and weighed the water.

With the mass loss method, most knew to weigh before and after strongly heating the sample and went on to describe how the results should be used. The missing details were commonly a suitable vessel for strongly heating, such as a crucible, and the idea of heating to constant mass.

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Candidates using the collection of water method often used an unsuitable container, such as a beaker. Fitting a condenser to a beaker would be challenging. However, the idea of heating until no more water was collected was seen more often.

A few included extra incorrect steps such as washing the residue before weighing.

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CHEMISTRY

Paper 0620/63
Alternative to Practical 63

Key messages

- In a quantitative task, if a reagent is added dropwise and then in excess, candidates should give observations for the dropwise addition and for the addition in excess; making it clear which observation is for dropwise addition and which for addition in excess.
- When plotting graphs, candidates should use a cross (X) or an encircled dot (⊙) to indicate a data point; 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, then the line, if drawn in pen, cannot be erased.
- Observations are those which can be seen. For example, 'fizzing' is an observation but 'hydrogen gas is produced' is not an observation as you cannot see that the gas is hydrogen.

General comments

Candidates successfully attempted all the questions and fully correct answers were seen to all question parts. 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.

Some responses might suggest that candidates have limited practical experience. This was particularly true on **Question 3**, the Qualitative Analysis question.

Comments on specific questions

Question 1

(a) Many candidates were able to correctly name the two items of apparatus and gave the expected answers of 'spatula' and 'tripod'. Common incorrect answers, which did not receive credit were identifying the spatula as a spoon or scoop (or a scoopula) and the tripod as just a stand.

(b) (i) The reason for heating being to speed up the rate of the reaction was well known, although some candidates incorrectly stated that it allowed more to react or dissolve.

(ii) Most candidates were able to identify a suitable item of laboratory apparatus for heating the reaction mixture. Bunsen burners, spirit burners and hot plates were all acceptable.

(c) Candidates were expected to use the information in the diagram to see that a solid remained after heating and conclude that this solid must be unreacted cobalt(II) oxide and so that was the reagent in excess. While many correct answers with clear explanations were seen, some candidates named substances that were a product rather than a reactant or named substances that were not involved in the process at all.

(d) (i) The process of filtration was well known.

(ii) The best responses clearly described the process of heating the solution until the point of crystallisation and then leaving it to cool. Some candidates did not gain full credit by stating 'it should be heated until all the water had evaporated' or by just naming the process rather than describing it.

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Question 2

(a) Nearly everyone filled in the columns with the volumes of sulfuric acid and water correctly. Most could also read the inverted measuring cylinders correctly, although the inversion did cause problems for some. Readings should be recorded in a consistent number of decimal places.

(b) Most candidates correctly plotted the values they recorded in the table. Points should be shown as crosses (X) or encircled dots (⊙) rather than just as small dots which become obscured by the graph line. While most candidates attempted to draw a smooth curve as instructed, some did not gain credit for the line as they either joined the points with straight lines or drew multiple lines.

(c) Many candidates performed well. To gain credit for the extrapolation, the extrapolation had to follow on smoothly from the graph line and not take a sudden change of direction.

(d) (i) Many well set out calculations were seen. The most common errors were incorrect rounding of an otherwise correct number or an error in the units.

(ii) This was very well answered with almost all candidates selecting the experiment with the largest volume of gas collected.

(e) (i) Almost all candidates could correctly state that a pipette was more accurate than a measuring cylinder.

(ii) This proved more demanding than **(i)**, however, many correct answers were still seen. Non-credit worthy answers often focused on the difficulty of using a pipette or its fragility. Some candidates thought that the fact that a pipette could only measure a set volume of 25 cm^3 was a disadvantage, but as that is the volume required it was not a problem in this instance.

(f) The expected, and often seen, answer was 'gas syringe'. A burette was not accepted as it is not graduated all the way to the tap and so the gas volume recorded would not be accurate.

(g) The best responses explained the advantage of the modified apparatus. Many answers suggested that candidates had done less practical work that usual this year and were not familiar with the problem of gas escaping before the bung was reinserted.

Question 3

(a) Some fully correct answers were seen. Many candidates seemed to be less familiar than in previous years with qualitative tests for anions and cations. As the question stated the aqueous sodium hydroxide was added dropwise and then in excess, observations should have been given for dropwise addition and then for addition in excess. Some fully correct answers were seen. It was also common for the precipitate colour to be incorrect or for incorrect observations, such as fizzing, to be given.

(b) Several candidates were not familiar with this qualitative test. Some fully correct answers were seen, however, it was common for the precipitate colour to be incorrect or for incorrect observations, such as fizzing, to be given.

(c) The positive test for chloride ions was better known than the test for chromium(III) ions.

(d) As the test described was the test for sulfate ions and solid **I** did not contain sulfate ions, the expected answer was that there would be no reaction or no change. A common error was for candidates to predict the formation of a precipitate or effervescence.

(e) Those candidates who referred to the results in the table almost always identified the gas as carbon dioxide. However, some candidates seemed to pick a substance at random, resulting in ionic solids, noble gases or metallic elements being suggested as possible gaseous products.

(f) Most candidates were able to link the flame test colour to potassium ions being present in solid **J**. However, the problems with identifying the gas in **(e)** resulted in fewer candidates identifying the carbonate ions.

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Question 4

The planning task involved devising an investigation to find which of three alcohols released the most energy on combustion. The expected answer involved finding the mass of fuel required to increase the temperature of a certain volume of water by a given amount or the time taken for the temperature to increase by a given amount.

A few excellent and well thought through answers were given. However, workable descriptions of a practical method were not common. Only a minority of candidates specified using a set volume of water for all three alcohols to heat and some candidates did away with the water all together and measured the temperature rise of the alcohol. Those candidates who did burn the alcohols to heat the water normally correctly stated that the more energy released by the alcohol, the greater the temperature rise of the water. However, it was common to omit the important step of measuring the starting temperature of the water, without which the temperature rise cannot be calculated.

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