CHEMISTRY

Paper 0620/11
Multiple Choice (Core)

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

General comments

Candidates found this a challenging paper. Questions which required more than one piece of information, such as those laid out in two columns or as multiple completion such as **Questions 32**, **35** and **36**, proved to be most difficult.

Candidates found **Questions 2** and **24** to have the least challenge.

Questions 5, **19**, **20**, **26**, **32**, **35** and **36** were most demanding.

Comments on specific questions

Question 5

Candidates recognised that ionic compounds have high melting points; few recalled that they do not conduct electricity when solid. Option **B** was the most common incorrect answer with few candidates choosing options **C** or **D**.

Question 6

Option **B** was chosen by a third of the candidates, where they recognised the nature of covalent bonding but not the number of outer shell electrons around carbon and hydrogen atoms in methane.

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Question 10

Candidates must take care when answering questions containing the word 'not'. Few of the candidates who performed less well overall answered this question correctly. Options **C** and **D** were chosen by two thirds of these candidates.

Question 13

Candidates confused both the hydrated form and the change needed to turn it white. Option **A** was the most common incorrect answer.

Question 17

Many candidates did not recognise the significance of adding an excess of copper(II) carbonate and chose to crystallise before removing this excess solid. Option **A** was therefore the most commonly chosen response.

Question 19

The correct answer was the most commonly chosen response. Some candidates chose option **C**, confusing the trend in both melting point and density of Group I elements.

Question 20

This was a challenging question which required candidates to recall both the physical properties and the reactivity of Group VII elements. Option **A** was chosen by almost a third of the candidates.

Question 23

Candidates who performed less well overall chose option **B**.

Question 25

This question required the candidates to identify that the structure shown represents an alloy and to recall that brass is an example of an alloy. Most candidates recognised both of these; some thought that graphite was an alloy and chose option **A**.

Question 26

This question was not well answered. Most candidates recalled that graphite does not react with dilute acids but did not recall the reactivity of iron and copper. Option **B** was the most common response.

Question 32

Most recognised the characteristic C=C group of an alkene. Many candidates confused the O–H group of an alcohol for that of a carboxylic acid. Option **C** was the most commonly chosen response.

Question 35

This was a challenging question and the distribution of responses suggests that many candidates were guessing. Option **D** was a common incorrect response amongst candidates who performed less well overall.

Question 36

This was one of the most challenging questions on this paper. Overall, candidates were more likely to choose one of the distractors than the key. Candidates should be reminded that ethanoic acid will react in a similar way as mineral acids when added to metals, carbonates and metal oxides.

Question 39

Many candidates did not recognise that the dissolved salts must be separated from sea water to make it drinkable. Filtration, option **C**, was a common incorrect answer.

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Question 40

Most candidates used the observation with aqueous sodium hydroxide to identify the presence of an ammonium ion. The carbonate ion test was less well recalled. Option **D** was a very common incorrect answer.

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Paper 0620/12
Multiple Choice (Core)

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

General comments

Candidates found this to be a particularly challenging paper.

Questions 1 and **6** had the least demand.

Questions 19, **28**, **29**, **34**, **35**, **36**, **37** and **39** had the greatest demand.

Questions 34, **35** and **36** on the reactions of organic functional groups and **Questions 37** and **39** on separation techniques were particularly poorly answered.

Comments on specific questions

Question 7

Candidate found this question on balancing a chemical formula difficult. A third of candidates chose option **C**, suggesting some confusion about the formula of a metallic element such as sodium.

Question 8

Some candidates appeared to ignore the brackets and found the mass of ‘$MgOH_2$’ rather than $Mg(OH)_2$. Option **C** was therefore a common incorrect answer.

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Question 16

This question on the identification of oxides based on their metallic or non-metallic nature was not well answered. Almost two thirds of candidates who performed less well overall thought that rubidium oxide would be an acidic oxide and option **B** was a commonly chosen response.

Question 17

This was found to be a challenging question. The question describes magnesium sulfate as soluble. Many candidates did not recognise the significance of this and chose an option which produced a precipitate. Option **B** was chosen by a third of the candidates overall.

Question 18

This question required the candidates to use two different pieces of information about two elements. Many candidates did not recognise the significance of the first statement, that the elements are in the same period. Option **B** was the most common incorrect response.

Question 19

The distribution of the responses suggests that some candidates were guessing.

Question 22

The correct response was the least popular option for candidates who performed less well overall. Candidates commonly confuse the inert gas, argon, with argan oil. In this question, many thought that argon was reactive with options **C** or **D** being popular incorrect choices.

Question 28

Relatively few candidates recalled that carbon burns to release heat energy in a blast furnace. Most thought that the reduction of iron(III) oxide was this key reaction and gave option **D**.

Question 29

This question on testing for water was the least well answered question on this paper. Over two thirds of the candidates thought that cobalt(II) chloride paper would test for either carbon monoxide or carbon dioxide. Options **A** and **B** were the most commonly chosen responses.

Question 34

This question on testing for unsaturation was not well answered. Option **B** was the most commonly chosen response.

Question 35

The most popular response across candidates of all abilities was option **C**. Candidates should read chemical names carefully, especially in organic chemistry. It is ethene, not ethane, that reacts with steam to form ethanol.

Question 36

Candidates should recall that acids contain H^+ ions. These ions are replaced by different cations when the acid reacts to form a salt. Most candidates did not remove the H^+ ion from ethanoic acid and gave option **A**.

Question 37

Most candidates confused the terms ‘solvent’ and ‘solution’ in this question. Option **D** was the most common response.

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Question 39

Candidates who performed less well overall were more likely to give any of the other options, although option **C** was the most common choice.

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Paper 0620/13
Multiple Choice (Core)

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

General comments

Candidates found this to be a very challenging paper. For many questions, candidates appeared to be guessing.

Candidates found **Questions 1**, **2** and **8** to have least demand and **Questions 4**, **5**, **9**, **10**, **15**, **17**, **19**, **20**, **34**, **36** and **40** to be more demanding.

Comments on specific questions

Question 3

Almost none of the candidates who performed less well overall answered this correctly. Options **A** and **C** were the most common incorrect answers.

Question 4

This question required the use of symbols for atoms or isotopes and was not well answered. The distribution of candidates' choices suggest that many were guessing.

Question 5

The question on the properties of ionic compounds was not well answered. Option **A** was a common answer.

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Question 9

Few candidates answered this question correctly. Some candidates confused the anode and cathode and chose option **A**. Almost a third of candidates chose option **D**.

Question 10

Most candidates thought that hydrogen and oxygen were outputs rather than inputs to the hydrogen–oxygen fuel cell. Option **B** was the most popular response.

Question 15

Thymolphthalein is a new indicator to this syllabus and many candidates either confused the colours and gave option **B** or they confused the indicator with methyl orange and gave options **C** or **D**.

Question 17

Many candidates did not recall that copper does not react with dilute acids or that metal carbonates react with acids to form a salt and gave options **A** or **C**.

Question 19

Most candidates recalled that potassium forms an alkaline solution (pH above 7) when added to water. Many did not use the diagram or knowledge of the syllabus to identify the low density of potassium and gave option **A**.

Question 20

Few candidates recalled the properties of Group VII elements. Many gave option **B**.

Question 34

This was a challenging question. A small majority of candidates recognised that Q must be an alkene; the alkanes were less well recognised. Option **C** was the most common response.

Question 36

Candidates should be reminded that ethanoic acid reacts in a similar way to mineral acids when added to alkaline solutions, metals or carbonates. Option **C** was the most common answer to this question.

Question 40

This question required knowledge of the test for sulfur dioxide. The overall distribution of choices suggests that many candidates were guessing.

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Paper 0620/21
Multiple Choice (Extended)

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

General comments

Overall, the candidates found this to be an accessible paper.

Questions 2, **4**, **29**, **30** and **39** were of the lowest demand.

Questions 17, **31**, **36** and **38** were the most demanding questions.

Comments on specific questions

Question 5

Questions which have the word ‘not’ in the question must be read carefully. Adding a tick or cross next to each statement may help candidates to identify the correct answer. Candidates who performed less well overall appeared to be guessing.

Question 8

Many candidates recognised the 4 : 8 ratio described by the equation but did not use the relative masses of the two substances. Option **C** was the most common answer.

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Question 15

Candidates who performed less well overall either confused weak and strong acids or assumed that lower pH corresponded to a weaker acid. Many of these candidates chose option **B**.

Question 17

The question was found to be quite challenging. There was evidence of guessing.

Question 21

Better performing candidates had little difficulty with this question whereas others were more likely to choose any of the other options. Option **A** was the most common incorrect answer. It is a common misconception that bromine is gaseous at room temperature and pressure.

Question 26

This question was not well answered. Most candidates recalled that graphite does not react with dilute acids but did not recall the reactivity of iron and copper. Option **B** was the most common response.

Question 28

Candidates who performed less well overall appeared to have been guessing.

Question 31

Methane contributes to the enhanced greenhouse effect by causing some of the thermal energy emitted from the Earth to be reflected back towards the Earth rather than being lost to space. This trapping of heat contributes to global warming. For this question, option **B** was the most common incorrect answer.

Question 36

Many candidates did not recall that the reaction of an alkene with bromine is an addition reaction. Option **B** was the most common answer.

Question 38

This was a challenging question. Peptide bonds are found in proteins and in nylon. To distinguish between their structures, candidates needed to determine whether the monomers would be diamines and dicarboxylic acids or amino acids. Many candidates did not make this distinction and chose option **A**. Few candidates thought that the structure showed ester linkages.

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Paper 0620/22
Multiple Choice (Extended)

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

General comments

Overall, candidates found this to be quite an accessible paper.

Questions 1, **2**, **3**, **5**, **13** and **22** had the lowest demand.

Questions 28 and **37** had the highest demand.

Comments on specific questions

Question 9

Candidates who performed less well were more likely to confuse the anode and cathode and so suggest option **C**. Some candidates chose option **B**, which would be the correct half-equation for a dilute acid or the cation of a reactive metal.

Question 10

Questions which contain the word ‘not’ must be read carefully. It may be helpful for candidates if they place a tick or cross next to each statement when deducing the correct answer. Option **D** was the most commonly given incorrect answer.

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Question 18

Most candidates recognised the need to filter the reaction mixture. Confusion arose as to whether it was the filtrate or the residue that should be collected. Candidates who performed less well overall were much more likely to choose option **C**.

Question 26

Most candidates correctly recalled that copper does not react with dilute acids but a significant number of candidates thought that magnesium would react violently with water and chose option **B**. Other candidates were more likely to think that magnesium is formed by heating its oxide with carbon and chose option **C**.

Question 28

Cryolite is the solvent into which purified aluminium oxide is dissolved. This occurs at a lower temperature than the melting point of aluminium oxide. Candidates appear to have confused this with lowering the melting point of aluminium and so chose option **D**.

Question 29

Nearly half of the candidates who performed less well overall thought that cobalt(II) chloride paper would identify carbon dioxide and chose option **A**.

Question 31

Nearly all the better performing candidates answered this correctly. Other candidates were more likely to choose option **B**

Question 32

Most candidates were able to identify one of the two addition products. Some candidates confused the addition product of ethene and bromine and choose option **C**.

Question 34

Some candidates found this a challenging question and did not recognise the structure of an ester and chose option **D**. The other two distractors were also more likely to be chosen than the correct answer for candidates who performed less well overall.

Question 37

The most popular answer to this question was option **A**. Candidates should recognise that in the substitution reaction, a hydrogen atom is removed and replaced by a chlorine atom. Methane with four hydrogen atoms could therefore give four different products.

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Paper 0620/23
Multiple Choice (Extended)

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

General comments

Questions 1 and **2** had the lowest demand.

Questions 5, **10**, **17**, **20**, **27** and **35** had the highest demand.

Comments on specific questions

Question 4

This calculation of relative atomic mass was a challenging question for some candidates. Option **A**, which would give a value which is too low, was a popular incorrect answer.

Question 5

Most candidates recalled the reason for the electrical conductivity of an ionic compound but confused the description of an ionic compound with that of a metallic compound. Option **C** was the most commonly chosen answer to this question.

Question 10

Most candidates confused the electrolysis of dilute halide solutions with concentrated solutions and chose option **B**.

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Question 11

There was evidence of guessing on this question.

Question 15

Many candidates confused the reaction conditions of the Contact process with those of the Haber process and chose option **B.**

Question 17

The most common response for this question was option **C**, which suggests that candidates were looking for the movement of oxygen rather than the movement of electrons. The equation given in **C** does not show any changes in oxidation number so is not redox.

Question 19

This question on the properties of strong acids was found to be challenging. Although there was a small preference for the correct answer, many candidates appeared to be guessing.

Question 20

The most common choice was option **B**. Candidates who performed poorly overall were more likely to choose any of the distractors over the key.

Question 27

More than half of the candidates chose option **B**. The equation shown in **B** would represent the reduction of iron(III) oxide. The question asks for a change which would prevent the rusting of iron. If iron(III) oxide has been formed, then rusting would already have occurred.

Question 35

Structural isomerism was not well recalled by many candidates. Option **D** was a commonly chosen answer.

Question 37

Candidates who performed less well overall appeared to be guessing, with each option almost equally likely to be chosen.

Question 38

Most candidates recalled that the most precise glassware to use in a titration would be the pipette and the burette. Some candidates confused the two and so chose option **D.**

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Paper 0620/31
Paper 3 Theory (Core)

Key messages

- Candidates would benefit from learning the syllabus definitions of chemical terms and processes.
- Candidates should avoid restating information given in the question as their answer.
- Interpretation of data and chemical reactivity was well done.
- The drawing of the dot-and-cross diagram was well done, as was the calculation of relative molecular mass.
- The descriptions of diffusion were often clear and well written.

General comments

Many candidates performed well on this paper, showing a good understanding of core chemistry. The standard of English was good, and few candidates left questions unanswered.

Chemical tests were not well recalled. For example, **Question 1(e)**, candidates commonly confused the green precipitate with the green colour of chlorine gas or the green flame test colour of copper. In **Question 2(d)**, the test for chlorine was confused with the test for chloride ions. In **Question 4(f)**, the indicator thymolphthalein appeared to be unfamiliar to many candidates.

Some candidates need to practice writing the formal definition for key chemical terms. For example, in **Question 3(d)(i)**, many candidates were unable to distinguish between a hydrated salt and an aqueous solution. Many definitions were too vague. In **Question 4(a)**, many candidates recognised that the number of protons and neutrons should be a part of their answer but did not recall that isotopes are described in terms of atoms which contain those particles. In **Question 5(c)(i)**, some candidates were unclear whether a metal was an essential part of an alloy or whether an alloy is a mixture or a compound. In **Question 7(b)**, most candidates recalled that members of an homologous series share the same functional group but did not show that they understood that the members must all be (organic) compounds. Some candidates suggested that the members of a homologous series must be hydrocarbons, which is only correct for alkane and alkenes but not alcohols or other functional groups. In **Question 8(c)**, most candidates recalled that covalent bonds are most commonly formed between non-metals but did not describe what the bond was. Candidates should recall that a bond is the attraction between the two bonded atoms and the shared pair of electrons.

Some candidates confused observations with inferences. In **Question 4(d)**, some candidates named chemicals as observations rather than the product and some named the electrode as an observation such as ‘cathode’ or ‘anode’.

Candidates should take care when writing chemical names. A common error in **Question 4(e)** was to give sulfide rather than sulfate. Similarly in **Question 7(c)**, ‘ethanoate’ was commonly mis-spelled. In **Question 7(e)**, the ‘e’ in ethene must be clear. Some candidates wrote in such a way that it was unclear whether they were giving ethene or ethane. Many candidates were unable to identify the ammonium ion, NH_4^+, in **Question 3(c)(ii).**

Comments on specific questions

Question 1

This was the best answered question on the paper. Most candidates were able to answer at least three parts of the question, with **(a)**, **(b)** and **(f)** most commonly correct.

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(a) Most candidates recalled nitrogen, N or N_2, as forming 78% of clean, dry air. The most common error was to suggest oxygen, O or O_2, or hydrogen, H.

(b) Most candidates identified helium as the only element shown which has atoms with a complete outer electron shell. The most common errors were to suggest oxygen, O, or hydrogen, H.

(c) Only a minority of candidates identified iodine, I. Most candidates confused the number of occupied electron shells with the group number and suggested nitrogen, N. A smaller number suggested iron, Fe, or bromine, Br.

(d) Many candidates confused the charge and group number and suggested magnesium, Mg, or calcium, Ca. A smaller number suggested elements which form ions with a charge of 1– such as chlorine, C*l* or bromine, Br.

(e) The cation test for iron(II) was not well recalled. It was most commonly confused with the green of chlorine gas. Copper, Cu, was also seen, although it was a less common error.

(f) The use of aluminium, A*l*, in food containers was recalled by the majority of candidates. Common errors included iron and a small but significant number of candidates suggested a gaseous element such as oxygen, O, or helium, He.

Question 2

Most candidates answered **Questions 2(a)(ii), 2(b)(i)** and **2(c)** well. **Question 2(a)(iii)** discriminated well between candidates with the candidates who performed less well gaining just one mark for the physical state or zero marks by not identifying the correct state at all. **Question 2(b)(ii)** also discriminated well with weaker responses often comparing the reactivity of iodine with potassium or by giving a vague answer such as 'they do not react'.

(a) (i) Many candidates did not use the boiling point information and did not realise that the melting point must be lower than the boiling point. Predictions of the melting point were frequently much too high. Some candidates found the positive and negative values difficult to interpret. They tended to find the average or middle point of +101 and +114 to suggest +108.

(ii) This question was well answered by most candidates.

(iii) Many candidates deduced the correct physical state but did not give a clear reason. Simply stating the melting and/or boiling points is not sufficient as an explanation. Candidates must state whether the given temperature is higher or lower than those values. Many candidates did not appear to engage with the data and suggested that –10 °C was between the melting point, –101 °C and boiling point, –35 °C. Some candidates did not use the correct element's data.

(b) (i) This question was well answered by most candidates. Neutralisation was the most common incorrect answer.

(ii) This question was not so well answered. Many candidates incorrectly described the relative reactivity of iodine and potassium or iodine and potassium chloride. Some were not clear which substances they were comparing, giving an answer such as 'it is less reactive'. The comparison must be clearly made between the reactivity of iodine and of chlorine (not chloride).

(c) Most candidates drew the correct electron configuration for a chlorine atom. A small number of candidates did not attempt the question or gave the configuration of a chloride ion, Cl^-.

(d) The test for chlorine was not well recalled. The most common error was to confuse it with the test for chloride ions using aqueous silver nitrate to produce a white precipitate. Some candidates confused the test with the flame test for copper ions, perhaps linking the green colours. A small number of candidates were awarded just one mark for identifying the use of litmus paper but not the correct observation.

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Question 3

Most candidates gained at least three marks in this question. **Questions 3(a), 3(c)(i) and 3c(iii)** being the most accessible. The effect of nitrates on aquatic life in **Question 3(b)(ii)** was not well recalled, with many guessing answers such as 'it kills fish' or it's toxic.

(a) Most candidates recalled that oxygen is essential for aquatic life. Hydrogen was the most common incorrect answer.

(b) (i) A wide range of possible answers were accepted for this question although most of those who answered correctly suggested sewage or harmful microbes. The most common incorrect answers showed some confusion between water pollutants with air pollutants. Gases such as carbon monoxide or methane were commonly seen.

Many candidates named a substance already listed in the question.

(ii) This question was not well answered. Many candidates confused nitrates in water with oxides of nitrogen and suggested breathing difficulties. Some candidates did correctly recall that the concentration of oxygen would fall, and some stated the term 'eutrophication' which was also accepted. The most common answers were to state that 'it kills fish' or that 'it's toxic', which are insufficient. Reference should be made to the level of oxygen present to sustain life.

(c) (i) Most candidates identified hydrogencarbonate either by name, formula or by its mass. The most common incorrect answer was silicate.

(ii) There were many incorrect answers including 'nitrogen hydroxide' or 'nitronium'. Some candidates suggested 'ammonia' or 'ammoniam'. The correct spelling should be given. A small number of candidates suggested 'nitrate', even though the correct formula of the nitrate ion is given in the table.

(iii) Most candidates answered this correctly. The most common incorrect answers were factors of 10 different. These were 4.4 or 44 mg.

(d) (i) The definition of hydration was not well recalled. Many candidates confused hydration with hydrogenation or aqueous solution. Although many recognised the association with water, the common incorrect answer 'it contains water' is too vague. Answers must be clear that the substance is chemically combined with water.

(ii) Many candidates recognised that the reaction is reversible but did not state how to reverse the reaction. Some candidates did not read the question clearly enough and described the colour changes. A description of the action taken (heating) was required rather than a description of what that action would do such as 'remove the water' or 'evaporate water'.

(e) Most candidates gained at least one mark in this question. The most common error was to suggest 2H rather than H_2 as the product. Some candidates suggested water, H_2O, would also be the product.

Question 4

Many candidates only showed a partial understanding of energy changes and electrolysis. In **Question 4(a)**, most candidates recalled that isotopes (of the same element) had different numbers of neutrons or the same number of protons, but few described that these isotopes were atoms. In **Question 4(d)**, many candidates did not read the question carefully enough and gave the cathode and anode rather than cathode and electrolyte. In **Question 4(e)**, some candidates gave chemical formulae rather than chemical names for the word equation.

(a) Most candidates gained one mark here. The most common error was to omit the word 'atom'. Isotopes must be described in terms of atoms. Candidates may describe atoms having different mass numbers, but they must not describe the atoms as having different *relative* masses because this is an average value of the isotopes not the mass of an individual isotope.

Candidates must also state that isotopes of the same element have different *numbers* of neutrons not that they are different neutrons.

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(b) Most candidates identified the number of protons in the sulfide ion. Slightly fewer identified the number of neutrons and few identified the number of electrons. Common errors were to give the mass number as the number of neutrons or to give the number of electrons as 16 or 14.

(c) (i) Most candidates answered this correctly. A small number transposed the reactants and products. Some candidates did not attempt the question at all.

(ii) Candidates were asked to use the figure given to answer this question. Although some candidates correctly described an exothermic reaction either in terms of the surroundings getting warmer or releasing energy, this does not show how the reaction pathway diagram shows that the reaction is exothermic. Candidates should have compared the relative energy of the reactants and the product from the diagram.

(iii) Most candidates answered this correctly. The most common incorrect answer was 'products'.

(d)(i) When adding labels to a diagram, candidates must take care that their arrow or line clearly identifies the part they are labelling. A label on the tank for the electrolyte is ambiguous.

Candidates should label the electrode when labelling the cathode or anode and not the wire or the power supply.

(ii) Although a few candidates were awarded full credit in this question, many did not answer the question. The most common incorrect answers were to describe the names of the electrodes as anode and cathode or to identify the ions that would be attracted to each electrode as anion and cation. When asked for observations, candidates should describe what they would see, e.g. 'bubbles of a colourless gas'.

The most common correct answers were to identify hydrogen produced at the negative electrode as 'bubbles' or 'fizzing'. Many candidates correctly identified hydrogen and oxygen but placed them at the wrong electrode. Some candidates suggested sulfur or graphite as products.

(e) Most candidates gained at least two marks in this question. Most identified sodium sulfate but a common mistake was to give sodium sulfide. Some candidates suggested hydrogen would be produced rather than water. Candidates should take care to give chemical names rather than formulae when asked to complete a word equation.

(f) Thymolphthalein was not a well-known indicator. Most candidates confused it with phenolphthalein or methyl orange.

Question 5

Candidates need more practice in answering questions on each stage in the blast furnace. In **Question 5(b)**, many candidates confused the processes. Some candidates simply restated the question and suggested 'it is used to extract iron'.

(a) Most candidates were able to identify at least one physical difference between iron and potassium. Common errors were to give chemical differences or to confuse the properties of the metals and so to describe potassium as being hard or having a high melting point.

Candidates should note that high melting point and high boiling point are not considered as two different marking points.

When asked to give two differences, candidates should follow the rubric of the question and only give two differences to reduce the possibility of giving a contradictory answer.

(b) The better performing candidates gave clear, well described answers to this question. Across all candidates, the use of carbon in the blast furnace was not well recalled. Many candidates incorrectly suggested that carbon was a catalyst in the extraction of iron from iron ore or that it was involved in the formation of slag. Some candidates repeated the question by stating that it is used to extract iron without reference to the processes involved.

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(c) (i) Most candidates recalled that a metal was required, although many did not use the word 'mixture' or thought that an alloy was a metal compound. Some candidates gave an answer which was too vague such as 'usually contains a metal', which may incorrectly suggest that a metal is not required or that the metal is mixed with a 'substance' rather than another element.

(ii) This question required candidates to make a comparison between an alloy and a pure metal. Many candidates suggested a property which was common to both such as 'it is malleable' or 'conducts electricity'. A comparative statement such as strong<u>er</u> or hard<u>er</u> was required.

(d) Most candidates gave the correct order of reactivity for these metals. Only a few gave the reverse order or an incorrect order. A few candidates confused the information given and used the word 'metal' in their answers.

Question 6

In **Questions 6(a)(i)** and **6(a)(ii)** and **6(a)(iii)**, candidates found it difficult to distinguish between the reaction rate and the time for the reaction to complete. When asked how to separate a solid and a solution, candidates seemed more likely to describe filtration than when they were given a specific example as showing in **Question 6(b).** The solubility rules for **Question 6(c)** were not well recalled.

(a) (i) Candidates found this to be a challenging question. The most common answer was 2, 1, 1.5.

(ii)(iii)
Many candidates recognised the effect on rate but did not distinguish between reaction rate and reaction time. Many gave vague answers which could be interpreted to mean time or rate such as 'faster'. Some candidates described both the rate and the time which was acceptable.

(b) Most candidates answered this correctly. 'Crystallisation' was the most common incorrect answer.

(c) Many candidates did not recall the solubility rules. Many incorrectly chose silver chloride, which is also covered by the cation tests.

Question 7

Candidates found the definition in **Question 7(b)** difficult with many only gaining one mark. Although many were not awarded both marks in **Question 7(c)**, some gave perfect answers with the correct spelling of magnesium ethanoate. The reactions which produce ethanol need more practice (**Question 7(e)**).

(a) (i) Most candidates were able to identify the carboxyl groups. A few chose the C=C double bond and a small number either did not answer the question or chose the –OH group. If a candidate changes their mind, they should make it clear which answer they are rejecting. Some candidates circled more than one different functional group and so could not be awarded credit.

(ii) This question was well answered but some candidates were careless with their chemical symbols. When writing a chemical formula, the subscripts must be clearly lower than the chemical symbols and those symbols must be in uppercase for carbon, hydrogen and oxygen.

(iii) Many candidates identified the correct colours but reversed the order.

(b) Few candidates were awarded full credit for this question. Those that were awarded one mark stated that members of the same homologous series shared the same functional group. A small number of candidates incorrectly suggested they shared a similar functional group. Few candidates stated that the substances are all molecules or compounds, with many confusing homologous series with groups from the Periodic Table.

(c) Candidates are expected to use the correct spelling using IUPAC nomenclature. Many candidates gave near-miss spellings for ethanoate such as 'ethanate' or 'ethanoic'. A small number incorrectly suggested 'magnesium hydroxide'. Candidates should recall that acids such as ethanoic acid will react to give similar products to those of mineral acids. Its reaction with magnesium will produce hydrogen and not water.

(d) This question was well answered with most candidates being awarded full credit.

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(e) Most candidates gave the reaction mixture for fermentation, glucose or starch and yeast rather than the other method (addition) required by the question. Some candidates may have written the correct answer, ethene, but they wrote in such a way that it was hard to determine whether they had written 'ethene' or 'ethane'. If the answer is ambiguous then credit cannot be awarded.

A significant number of candidates did not attempt this question.

Question 8

In **Question 8(a)**, some candidates showed poor understanding of the difference between chemical and physical properties. Many answers were vague such as giving 'factories' as a source of oxides of nitrogen and 'causes illness' or 'are harmful' for their effects. Most candidates identified a suitable pH for an alkaline solution in **Question 8(c)(iii)**. The longer descriptive answers given for **Question 8(c)(iv)** were often detailed and accurate.

(a) When asked for two properties, candidates must take care to only give two properties to avoid possible contradictions. They should also note that low boiling point would be the same marking point as low melting point. Many candidates simply repeated the property from the question or gave chemical rather than physical properties.

(b) (i) When asked for the source of pollutant gases, candidates frequently suggested 'factories' which is too vague. Similarly, 'burning fuels' was incorrect because hydrogen, when uses as a fuel, does not produce polluting gases.

(ii) The problems associated with oxides of nitrogen were not well recalled. Answers needed to give a clear problem with respiration or breathing or irritation of the skin or eyes. Many candidates restated the information in the question and suggested 'acid rain'. Some confused oxides of nitrogen with other gaseous pollutants or nitrates.

(c) (i) This question was the least well answered question on this paper. The formal definition was not well recalled. Very few candidates recognised that a covalent bond would connect two atoms. Although most candidates correctly answered **(c)(ii)**, few recognised that the bond would contain two shared electrons. The most common error was to describe properties of covalent compounds such as low melting point or poor conductivity. Some candidates gave answers which were close such as 'non-metals which share electrons'.

(ii) Most candidates were awarded full credit here. The most common error was to give only one non-bonding electron or to omit the non-bonding electrons completely.

(iii) Most candidates answered this question correctly.

(iv) Candidates often gave well-written and clear descriptions to describe diffusion. Many candidates gained full credit and covered all the possible marking points. Most candidates identified that the process was diffusion and that there was movement from higher concentration to lower concentrations of ammonia. Those that did not gain all three marks often gave an answer that did not use particles or molecules of ammonia and simple described the movement of gas. Some candidates spent more time describing why the litmus changed colour rather than the movement of particles to the litmus.

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Paper 0620/32
Paper Theory (Core)

Key Messages

- Questions where the candidate had to match the symbol of an element to a statement were answered well. It was obvious that many candidates had been practising these types of questions. The matching of the chemical test in this section to the correct element was not answered well, as in **Question 1(e)**. Many candidates did not know the element that 'is a grey-black solid at room temperature', in **Question 1(d)**.

- Questions requiring simple answers to calculations were usually answered well, as were questions involving balancing equations. Candidates were able to easily calculate the relative molecular mass of a given compound in **Question 7(f)**.

- Questions on the more detailed aspects of the kinetic particle theory were answered better than in previous years. However, some candidates needed to answer these longer style questions in more detail using the correct Chemistry terms. There was also a tendency for some candidates to forget to mention the words 'molecules' or 'particles'.

- 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. Better performing candidates tend to read questions properly and do not quickly skip through them. Practice of reading and interpreting data based questions should also be prioritised.

- Answering of chemical test questions was poorly done, showing large gaps in the knowledge of many candidates. This is a part of the syllabus that needs to be practiced. Candidates struggled with 'describe a test for iodide ions' in **Question 2 (b)(iii)** and 'describe a test for unsaturated compounds', in **Question 7(b)(ii)**.

- Organic questions were answered reasonably well, and some candidates could draw structures of organic compounds. The displayed formula of ethene in **Question 7(b)(i)** was drawn reasonably well. However, some candidates showed five bonds around each carbon and the wrong numbers of hydrogen atoms in their displayed formulas.

- Environmental Chemistry questions were answered poorly, which showed more revision and practice needs to be carried out on these topics. **Question 3 (a)(i)** and **(ii)** were examples where candidates had to 'name two other substances found in water that are harmful to aquatic life' and 'why phosphates are harmful to aquatic life'. Also, the questions on methane 'as an air pollutant' showed more revision and practice needs to be done on these types of questions, as in **Question 8 (b)(iii)** and **(iv)**. **Question 8 (c)(ii)**, 'state two methods of reducing acid rain' was also answered very poorly.

- Definition questions were answered incorrectly by some candidates as in the definition of 'the term exothermic' in **Question 4 (c)(i)** and 'diatomic' in **Question 4 (a)**. For some candidates, more learning and practice of the definitions stated in this syllabus needs to be carried out during the delivery of this course.

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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 this year achieving very low marks and leaving vast amounts of the paper blank. The general standard of answering was comparable with previous years, if not slightly better. It was evident that many candidates are now using past paper practice as part of their revision program, but more revision is needed on some aspects of the syllabus.

Misinterpretation of the rubric did happen in some cases. The most common either misinterpretation or simply not reading of the rubric was in the question that asked, 'write the formula of the ion present in all alkalis'. Some candidates wrote a general equation for neutralisation or a specific equation for neutralisation and did not read the word 'formula'. In **Question 4 (f)(ii)**, many candidates did not read the part of the question that stated, 'the electrolysis of concentrated aqueous sodium chloride' and therefore did not realise that the sodium chloride was dissolved in water so this would also take part in the electrolysis itself. Many candidates, therefore, got this particular question incorrect. The other misinterpretation was in **Question 8(a)** where candidates thought that a difference in reactivity was a physical property typical of a non-metal and therefore got this question wrong. The balancing of equations was much better this year, showing that the candidates had practiced these as part of their revision from past papers. Definitions from across the syllabus were poorly done and candidates need to concentrate on them both when being taught for the first time and during the revision period.

Most candidates were able to deduce the molecular formula of an organic compound as in **Question 7 (a)(ii)**. Some struggled with 'deduce the number of protons, neutrons and electrons in the chloride ion shown' in **Question 4(b)**. More practice is needed on atomic structure questions like this during revision. In 'predict the physical state' of the element at a certain temperature, most candidates could give the state and a very good reason, which showed practice and revision of past paper questions. Data handling type questions could have been answered better. Candidates made slight mistakes, and some were not precise enough when answering these types of questions. Candidates did not struggle too much drawing the structure of ethene in **Question 7 (b)(i)**. This showed that candidates had been doing lots of practice in the drawing of molecules listed in this part of the syllabus.

Candidates need to be more explicit when talking about certain concepts and not use the words 'it' and 'they' to answer questions. 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 did reasonably well on this question about elements in the Periodic Table. Some struggled with **(d)** and **(e)**. Most candidates knew which gas forms 21% by volume of clean, dry air in **(a)** but lots did not know which of the elements shown in the Periodic Table was the 'grey-black solid at room temperature'.

(a) Most candidates could answer this question and knew which gas forms 21% by volume of clean, dry air. However, some candidates thought it was 'nitrogen' or 'helium'.

(b) Some candidates knew the answer to this. However, more practice needs to be done by candidates and the connection between where the element is in the Periodic Table and its occupied electron shells.

(c) Many candidates got this question correct, showing good knowledge of groups and number of electrons in the outer shell.

(d) Candidates struggled to recall that out of the elements shown, only 'iodine' is a 'grey-black solid at room temperature'. Very few candidates answered this correctly.

(e) The chemical tests proved to be where the candidates struggled the most. Few candidates could say that 'chromium' formed 'an ion that gives a green precipitate on addition of aqueous ammonia'.

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(f) This was perhaps answered the best of the short first questions on this paper. Most candidates knew that ‘copper’ is ‘used in electrical wiring because of its ductility’.

Question 2

Some parts of this question were answered well, showing practice of similar questions and past papers. For example **(a)(i), (a)(ii)** and **(b)(i)**. Candidates struggled with the chemical test in **(b)(iii)** and trends in reactivity of the halogens in **(b)(ii)**.

(a) (i) Most candidates could give a value in the required range for the ‘boiling point of iodine’ showing practice of this type of question. However, some candidates gave a range that was outside of the range required. Candidates would be better to just quote one value.

(ii) Many candidates got this correct and could easily quote a correct value in the required range. A certain value needs to be quoted and not just ‘lower than’ or ‘higher than’ a certain value as this is not an allowable answer.

(iii) There were some very good answers seen to this question. A vast majority of candidates got the physical state of bromine as being a ‘liquid’ and many also got the correct answer. Most of these were able to say that the temperature was ‘between the melting and boiling point’ or it was ‘higher than the melting point and lower than the boiling point’ in order to be in the liquid state. However, some candidates did just quote figures, which is not the correct answer.

(b) (i) Many candidates could write this word equation. When asked for a word equation, candidates need to write this and no other form of equation. ‘Iodide’ and ‘potassium bromine’ were seen in some instances. Other incorrect products were also seen, such as ‘carbon dioxide’ and ‘water’.

(ii) This type of question on the displacement reactions and reactivity of the halogens was answered poorly. Few candidates could say that ‘bromine was more reactive than iodine’. Most answers wrongly mentioned ‘potassium bromide’ or ‘potassium’.

(iii) Chemical tests were answered poorly by candidates showing a lack of revision in this area. Very few candidates could recall the test for ‘iodide ions’ and some of those that did then went onto to recall the wrong coloured precipitate or put the correct colour of ‘yellow’ but then omit the word ‘precipitate’ which did not gain credit.

Question 3

Candidates struggled with this question especially **(a)(i), (ii)** and **(c)(i)** and **(ii).** However, candidates did much better on **(b)(i)** and the calculation in **(b)(iii)**.

(a) (i) Candidates struggled to ‘name two other substances found in water which are harmful to aquatic life’. Some of their answers were too generic so could not be awarded credit. The most popular correct answers were ‘plastics’, ‘sewage’ and ‘microbes’.

(ii) Many candidates struggled with this question and only the better performing candidates answered this question correctly. This was one of the most poorly answered questions on the whole paper and is an area of the syllabus that candidates should concentrate on when doing revision.

(b) (i) This question was answered extremely well by candidates showing many of the candidates had practiced this type of question before. Not many wrong answers were seen at all.

(ii) Some candidates did get this question correct, with the right answer of ‘nitrate’. However, many candidates did not identify this ion or a similar one. Popular wrong answers of ‘nitrogen oxide’, ‘nitric oxide’ and ‘nitrate oxide’ were seen. Some candidates thought the correct answer was ‘nobelium’. More recall testing of the candidates’ knowledge is recommended for this area of the syllabus.

(iii) This was one of the maths questions on this paper. Candidates did very well on this question. Many candidates calculated the correct answer, showing that practice had been done on this type of question. Some incorrect numerical answers were also seen.

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(c) (i) Candidates struggled on this question and wrote 'by using heat' you could change the colour. Candidates needed to realise that by 'adding water' or 'hydrating' the white copper(II) sulfate it would go blue. Incorrect answers included 'heating' or 'boiling'.

(ii) This was not very well answered, with only the better performing candidates giving a correct response. All the range of given terms were seen here. 'Anhydrous' was the correct answer.

(d) Most candidates seemed to be able to balance this equation but could not recall the correct product. Sometimes '2H' was seen instead of 'H_2' for the correct product and quite a few times 'H_2O' was seen as the incorrect product. More practice is needed here.

Question 4

Candidates found this longer question particularly hard compared to other questions on the paper. Part **(c)(ii)** and **(e)(i)** were answered well, whereas candidates struggled with most of the other parts, especially **(c)(iii)**, **(e)(ii)** and all of **(f)**, which was an electrolysis question.

(a) Some candidates did well on this question and knew that 'diatomic' meant that it was a 'molecule that contained two atoms'. However, some candidates thought that it was a 'molecule that contained two or more atoms' or 'had two molecules in it' which was incorrect. More practice of definitions would be beneficial here.

(b) Some candidates answered this question well but there were many candidates who struggled with the working out of protons, neutrons and electrons. Some candidates could work out the protons and neutrons, but many could not work out the number of electrons in the ion. More practice when revising this would be beneficial here, especially with ion structures.

(c) (i) Many candidates could get the first half of the definition correct, which was a 'reaction that transfers thermal energy' or a 'reaction that gives off heat' but did not refer to 'to the surroundings'.

(ii) Many candidates gained credit here and could write the correct formulae on the correct part of the diagram. More care when copying the formulae across could have been taken by some candidates and some candidates just wrote 'reactants' and 'products', which was incorrect. Completely writing the formulae on the line was essential here and candidates needed to take more care when writing the formulae in the correct places. Some candidates were very careless and did not write the formulae across the line.

(iii) This was a poorly answered question. Many candidates could not use the diagram to 'show that the reaction was exothermic'. Many struggled on this question and often just said that 'heat was given off' instead of stating that 'the energy of the reactants is greater than the energy of the product' or 'the arrow is pointing downwards'. Some candidates got mixed up with 'reactants' and 'products'.

(d) Some candidates could answer this question and had clearly learned the colours of the required indicators in acidic and alkaline conditions. However, there were many candidates that did not know the correct colour or got the colours mixed up.

(e) (i) This question was answered well by most candidates. They were able to complete the word equation for the given reaction remembering that hydrochloric acid gives a chloride salt. However, some candidates gave formulas for the products made instead of the required names.

(ii) Candidates struggled with this question and lots of different answers were seen. Few candidates knew the correct answer and lots of candidates put down equations instead of 'the formula of the ion'. For example, 'acid + alkali → salt + water'. Few candidates wrote down the correct hydroxide ion symbol and some candidates wrote down the incorrect hydrogen ion symbol.

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(f) (i) This was the first of two electrolysis questions. This part was answered much better than the second. Some candidates could label 'the anode' but sometimes struggled to put a correct label at a correct position. The piece of apparatus needed to be labelled with a concise arrow and not just the name written by the side of it, as it is must be clear where the candidate is meaning. The anode is not the wire or the positive sign at the power supply. The label must be pointed to the rod. Good responses used an arrow for clarity. More candidates labelled 'the electrolyte' correctly. Better performing candidates used an arrow and ensured this did not simply point to the beaker but to the liquid in the beaker.

(ii) This electrolysis question was answered poorly by many candidates, showing a lack of knowledge of what products are produced and what the observations are at the electrodes for a 'concentrated aqueous solution' of a particular salt. Candidates thought the products were mainly 'chlorine' and 'sodium' as they did not read the 'aqueous' part. Few candidates could say that 'hydrogen' was the product at the 'negative electrode'. More revision practice is needed here on predicting the products of the electrolysis of aqueous solutions and their observations. This can often be demonstrated using experiments, video clips and simulations.

Question 5

Candidates found this question about metals reasonably straight forward. Many could 'name the main ore of iron' as in **(a)(i)** and had clearly practiced the spelling of it and could also 'state one method of preventing rusting' easily as in **(b)**. Part **(c)** was answered reasonably well.

(a) (i) Many candidates could 'name the main ore of iron' and had clearly practiced the spelling of it. Some candidates had very poor spelling of hematite and some also suggested 'bauxite', which is incorrect.

(ii) Candidates struggled slightly with this. Most could identify one of the 'substances which react in the blast furnace to produce carbon monoxide' but could not identify both. Quite a lot of candidates thought the correct answers were 'carbon' and 'oxygen' rather than 'carbon' and 'carbon dioxide'.

(b) This was a very well answered question by most candidates. Most candidates knew 'one method of preventing rusting' which showed much revision of this particular topic. The most popular answer was 'painting' followed by 'oiling'. Candidates need to be reminded that 'coating with a reactive metal' is not accepted. However, 'coating with a **more** reactive metal' is correct.

(c) This was well answered, showing that candidates had practiced these types of questions when doing their past papers. Many candidates did get 'chromium' and 'beryllium' in the incorrect order and struggled with identifying which order they should be in. Some candidates thought that 'metal' was one of the answers.

Question 6

Candidates found some of this question challenging. They especially struggled with comparing the 'time taken' for reactions in **(a)(ii)** and **(a)(iii)**. Some candidates struggled with the experimental question in **(b)** showing that more practice is needed on these experimental type questions. Candidates were not familiar with the solubility rules in **(c)**, showing that this type of question must be practiced more.

(a) (i) This was answered exceptionally well, and most candidates could match the 'time taken' to the 'size of the pieces of calcium carbonate' given.

(ii) Candidates struggled with this question, which was asking for the 'time taken' instead of the 'rate of reaction'. Many candidates went onto read the question incorrectly and to talk about the 'rate' becoming 'faster' instead of the correct answer of 'less time taken' or 'takes a shorter time'.

(iii) Candidates also mistook this for asking about the 'rate of reaction' instead of the 'time taken'. Candidates wrote down that the 'rate decreases' or the reaction was 'slower', instead of that it 'takes a longer time' or 'less time is taken'. More practice on these types of questions should be carried out.

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(b) This question used the candidates' experimental knowledge to answer a question regarding 'the process used to separate the unreacted calcium carbonate from the rest of the reaction mixture'. Some candidates struggled with this experimental based question and did not know the correct answer of 'filtration'. Other incorrect separation techniques were seen, for example, 'fractional distillation' and 'crystallisation'. More practice of applying the different separation techniques to different practical scenarios is needed.

(c) This part was a solubility rules question where candidates had to identify which one out of four given compounds was insoluble in water. In order to answer this question, candidates needed to know the solubility rules and many candidates did not appear to.

Question 7

Candidates did reasonably well on this question especially on **(a)(ii)**, **(c)(ii)** and **(f)**. They struggled on **(a)(i)**, **(a)(iii)** and **(e)**. Most candidates could 'deduce a molecular formula of an organic compound' and work out a compound made in cracking but struggled with distinguishing an 'alcohol functional group' in an organic compound and naming the salt produced when 'ethanoic acid reacts with sodium'.

(a) (i) Candidates found this question hard and not many could 'draw a circle around the alcohol functional group'. Many drew the circle around the OH group of one or both of the carboxylic acid groups or all three of the OH groups shown in the figure, which was incorrect. Some candidates also wrongly drew a circle around the carbon that was attached to the correct OH group which was also incorrect. More practice of identifying organic groups from displayed formulae is needed.

(ii) Many candidates had obviously practiced deducing the molecular formula of an organic compound. The elements can be placed in any order, but the numbers must be subscript and not superscript, which was seen in a few instances.

(iii) Candidates struggled with this mainly because they were not exact enough with their answers. The correct answer was that the 'compound was unsaturated' because it had a 'carbon-carbon double bond' and not just a 'double bond' or 'carbon double bond'.

(b) (i) Some candidates could 'draw the displayed formula of ethene'. However, many candidates put extra hydrogens in or forgot the double bond, which made their answer incorrect.

(ii) Few candidates knew that the answer was 'bromine water' and the colour change was 'turns colourless' or 'decolourises'. Some thought that the test was using 'bromide water' and many got the test mixed up with other chemical tests from other parts in the syllabus. More revision of the chemical tests stated in the syllabus is needed.

(c) (i) Many candidates did know the 'two conditions for cracking' and could state a 'catalyst' and a 'high temperature'. Some candidates tried to quote values for temperature which had to be within a certain range in order to gain credit. 'Warm' is not a high enough temperature.

(ii) Many candidates got the correct answer for this question on the 'cracking of decane' and could work out that the numbers of each element on both sides of the equation must equal each other. This was a very well answered question.

(d) This was a very well answered question on the ways of manufacturing ethanol. Most candidates knew that 'fermentation' was the correct answer. However, other wrong answers such as 'oxidation' and 'thermal decomposition' were also seen.

(e) Candidates struggled with this part on the naming of 'the salt formed when ethanoic acid reacts with sodium', showing that more practice is needed. Many thought it was 'sodium hydroxide'.

(f) Candidates did very well on this. Most candidates could calculate the correct answer and few incorrect answers were seen here.

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Question 8

Candidates found parts of this last question hard, especially **(b)(ii)**, **(b)(iii)** and **(b)(v)**. These were questions on methane and its sources and effects. Part **(c)(ii)** was the question on this paper that candidates struggled with the most, showing more work needs to be carried out on the environmental chemistry topics. However, **(b)(i)** and **(c)(i)** were answered well. Part **(c)(iii)**, on the kinetic particle theory, was answered well.

(a) Most candidates could provide at least one of the two required 'physical properties' for this question. Some found it harder as it was the 'physical properties' of non-metals which was required and not metals. Some candidates were confused about what a 'physical property' was and wrote about 'chemical properties', like inertness. Candidates must not simply state 'non-conductor' as this will not gain credit. They should say what it is a non-conductor of and in this question, it was 'heat' and 'electricity'. Other candidates wrongly just wrote down names of non-metals. However, in most cases this was a well answered question.

(b) (i) This dot-and-cross question was another well answered question. Most of the wrong answers were when candidates put extra electrons on the hydrogen atoms. Candidates obviously had been practicing these dot-and-cross diagrams.

(ii) Candidates found this question on the 'general formula for alkanes' hard and lots did not know what it was. Some wrote down the general formula for an alkene. Many candidates just wrote down a name of an alkane, such as 'ethane'.

(iii) Candidates struggled with this question and did not know 'one source of methane in the air'. This environmental chemistry question was hard for most candidates and those that did try to answer it were not specific enough and therefore did not gain credit.

(iv) This was also a hard question for most candidates. Many did not know 'one adverse effect of methane in the air'.

(v) Candidates struggled on this question and did not know the 'other compound formed during the incomplete combustion of methane'. Many wrote down 'hydrogen'.

(c) (i) Candidates did very well on this question and most were able to circle 'the pH value that is acidic' of the pH values that were given. This showed a very good understanding of this topic.

(ii) This was the question on the paper that candidates struggled with the most. Very few candidates could 'state two methods of reducing acid rain'. Very few could state at least one method.

(iii) The 'kinetic particle theory' question was the last question on this paper. The main mistakes were not being specific and talking about 'molecules' or 'particles'. Some candidates wrote down that 'molecules spread from a low concentration to a high concentration', which was incorrect.

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Paper 0620/33
Paper 3 Theory (Core)

Key Messages

- Questions where candidates had to match the symbol of an element to a statement were answered well. It was obvious that candidates had been practising these types of questions. However, the matching of the chemical test to the correct element was not answered well, as in **Question 1(e)**. Many candidates did not know the element that 'forms an oxide that contributes to acid rain' in **Question 1(b)**.

- Questions requiring simple answers to calculations were usually well answered, as were questions involving balancing equations. Candidates were able to easily calculate the relative molecular mass of a given compound in **Question 7(c)**.

- Questions on the more detailed aspects of the kinetic particle theory were answered better than in previous years. Some candidates needed to answer these longer style questions in more detail using the correct chemistry terms. There was also a tendency for some candidates to forget to mention the words 'molecules' or 'particles'.

- 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 to understand what exactly is being asked. Practice of reading and interpreting data based questions should also be prioritised.

- Performance on chemical test questions was poor and showed large gaps in the knowledge of many candidates. This is part of the syllabus that needs to be practiced more often. Candidates struggled with 'State a test for sodium ions' in **Question 2(b)(ii)** and 'Describe a chemical test to distinguish between a saturated and an unsaturated compound' in **Question 7(a)(iii)**.

- Organic questions were answered reasonably well, and some candidates could draw structures of organic compounds. The displayed formula of ethanol was asked for in **Question 7(b)(ii)** and this was drawn reasonably well. However, some candidates showed five bonds around each carbon atom and the wrong numbers of hydrogen atoms in their displayed formulas. Candidates often forget to display the covalent bond between the oxygen and hydrogen in the alcohol functional group.

- Environmental chemistry questions were answered poorly and shows more revision and practice needs to be carried out on these topics. **Questions 3(a)(i)** and **(ii)** were examples where candidates had to 'Name two other substances present in polluted water which are harmful to aquatic life' and 'State why sewage can cause disease'. Also, the question on carbon dioxide in **Question 8(b)** shows more revision and practice needs to be done on these types of questions.

- Some candidates answered definition questions well, as in **Question 8(c)(iii)**. However, more learning and practice of the definitions stated in this syllabus needs to be carried out.

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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 who performed poorly and left vast amounts of the paper blank. It was evident that many candidates are now using past paper practice as part of their revision program.

Misinterpretation of the rubric happened in some cases. The most common either misinterpretation or simply not reading of the rubric was in the question that asked 'Write the formula of the ion present in all acids'. Some candidates wrote a general equation for neutralisation or a specific equation for neutralisation and did not read the word 'formula'. Not reading the question properly was a key factor for some candidates making mistakes in their answers. The other misinterpretation was in **Question 8(a)**, where candidates thought that a difference in reactivity was a physical property typical of a non-metal. Many candidates were able to balance equations and showed that the candidates had practiced these as part of their revision from past papers. Definitions from across the syllabus were reasonably answered but candidates still need to concentrate on these both when being taught them for the first time and during the revision period.

Most candidates were able to deduce the molecular formula of an organic compound in **Question 7(a)(ii)** but some struggled with 'Deduce the number of protons, neutrons and electrons in the bromide ion shown' in **Question 4(a)**. More practice is needed on atomic structure questions during the revision period. Most candidates were able to 'Predict the physical state' of an element at a certain temperature and provide a sensible reason. Data handling type questions could have been answered better. Candidates made errors by not being precise enough when answering these types of questions. Candidates were able to draw the structure of ethanol in **Question 7(b)(ii)**. This showed that candidates had been doing lots of practice in the drawing of molecules listed in this part of the syllabus. Candidates need to be more explicit when talking about certain concepts and not use the words 'it' and 'they' to answer questions. The standard of English was reasonably good. Some better performing 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.

Question 1

Candidates did reasonably well on this question about elements in the Periodic Table. Some struggled with **(b)** and **(e)**. Most candidates knew which of the elements shown 'is present in diamond' in **(a)** but many did not know which of the elements shown in the Periodic Table 'forms an oxide that contributes to acid rain' and which of the elements shown 'forms an ion that gives a red-brown precipitate on addition of aqueous ammonia', showing that candidates needed to do more revision and practice on the chemical tests outlined in this syllabus.

(a) Most candidates could answer this question and knew which of the elements shown 'is present in diamond'. 'Chromium' and 'calcium' were both common wrong answers.

(b) Candidates struggled with this question and found it very hard. Few candidates knew that from the elements given, 'nitrogen' is the one that 'forms an oxide that contributes to acid rain'.

(c) More practice needs to be done by the candidates on this type of question, which looks at the connection between where the element is in the Periodic Table and its occupied electron shells.

(d) Many candidates got this question correct, showing very good knowledge of which elements form which ions in the Periodic Table. The correct answer was 'lithium', as it 'forms an ion with a charge of +1'.

(e) The chemical tests proved to be where the candidates struggled the most. Few candidates could say that 'iron' forms 'an ion that gives a red-brown precipitate on addition of aqueous ammonia'. The chemical tests mentioned in this syllabus must be revised and learned.

(f) This question was perhaps answered the best of the short first questions on this paper. Most candidates knew that 'aluminium' is 'used in the manufacture of aircraft because of its low density'.

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Question 2

Candidates did much better on this question than **Question 1**. Some parts were answered well, **(a)(i), (a)(ii)** and **(b)(i)**, showing practice of similar questions and past papers. Candidates struggled with the chemical test in **(b)(ii)**.

(a) (i) Most candidates could give a value in the required range for the 'boiling point of chlorine', showing much practice of this type of question. However, some candidates gave a range with a value that was outside the accepted range. Better performing candidates quoted one value only and not a range of values.

(ii) Many candidates got this correct and could easily quote a correct value in the required range. A certain value needs to be quoted and not just 'lower than' or 'higher than' a certain value. However, in general, this question was answered well. Most candidates could quote a value for the 'density of fluorine at room temperature and pressure'.

(iii) The majority of candidates got the physical state of iodine as 'solid'. Most of these were able to say that the temperature was 'below the melting point' or 'lower than the melting point' in order to be in the solid state. However, some candidates simply quoted figures, which is not a reason.

(b) (i) Many candidates could write this word equation. When asked for a word equation, candidates need to write this and no other form of equation. 'Bromide and 'sodium chlorine' were seen in some instances. Other incorrect products were also seen such as 'carbon dioxide' and 'water'.

(ii) Chemical tests were answered poorly by candidates, showing a distinct lack of revision of these. This test for 'sodium ions' was no exception. Very few candidates could recall this test and some of those that did then went onto to recall the wrong coloured flame or incorrectly stated a 'yellow precipitate'.

Question 3

Some candidates struggled with this question especially with **(a)(i), (ii), (b)(ii)** and **(c)(i).** However, candidates did much better on **(b)(i)** and the calculation in **(b)(iii)**.

(a) (i) Candidates struggled to 'name two other substances present in polluted water which are harmful to aquatic life'. Some of their answers were too generic. The most popular correct answers were 'plastics', 'phosphates' and 'microbes'.

(ii) Many candidates struggled with this question and this was one of the most poorly answered questions on the whole paper.

(b) (i) This question was answered extremely well by candidates, showing many had practiced this type of question before. There were few wrong answers seen.

(ii) Some candidates got this question correct. However, many candidates did not identify this ion or a similar one. Popular wrong answers of 'sulfur oxide', 'sulfuric oxide' and 'sulfate oxide' were seen. Increased recall testing of the candidates' knowledge may help.

(iii) Candidates did very well on this question. Many calculated the correct answer, showing that practice had been done on this type of question. Some incorrect numerical answers were seen.

(c) (i) A lot of candidates struggled on this question and some put down 'by adding water you could change the colour'. Candidates needed to realise that by 'heating or 'raising the temperature' of the pink cobalt(II) chloride, it can be changed to blue cobalt(II) chloride.

(ii) This was not a very well answered question. All the range of answers were seen here, with candidates thinking it could be any one of the answers in the list. 'Hydrated' was the correct answer.

(d) Most candidates were able to balance this equation but could not identify the correct product. Sometimes '2H' was seen instead of the correct 'H_2' for the product and quite a few times 'H_2O' was seen as the incorrect product.

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Question 4

Candidates found this longer question particularly hard compared to other questions on the paper. Parts **(b)**, **(c)(iii)** and **(d)(iii)** were answered well, whereas candidates struggled with most of the other parts, especially **(c)(i)** and **(d)(i)** and **(d)(ii)**.

(a) Some candidates answered this question well but there were many candidates who struggled with working out the protons, neutrons and electrons. Some candidates could work out the protons and neutrons, but many could not work out the number of electrons in the ion. More practice when revising would be beneficial here, especially with atomic structures of ions.

(b) (i) Many candidates could write the correct formulae on the correct part of the diagram. More care when copying the formulae across could have been taken by some candidates and some candidates just wrote 'reactants' and 'products', which was insufficient. Writing the formulae on the line was required here.

(ii) Many candidates could not use the diagram to 'show that the reaction was endothermic'. Many struggled on this question. Weaker responses stated, 'heat was taken in' instead of stating that 'the energy of the products is greater than the energy of the reactant' or 'the arrow is pointing upward'. Some candidates got mixed up with 'reactants' and 'products'. More practice on these styles of questions is needed.

(iii) Most candidates got the answer for this question correct. They were able to pick out the correct answer of 'surroundings'.

(c) (i) Candidates struggled with this question and many different answers were seen. Few candidates knew the correct answer and lots gave equations instead of 'the formula of the ion'. For example, 'acid + alkali → salt + water'. This indicated that they did not understand what the question was asking. Few candidates wrote down the correct hydrogen ion symbol and some wrote down the incorrect hydroxide ion symbol.

(ii) Candidates struggled with this question. Some stated 'carbon dioxide' and 'water' but did not know 'salt' and actually named a salt instead. For example, they answered 'sodium chloride' instead of the generalised 'salt'. Formulae were also seen which were incorrect as the question was asking for a 'word equation'. Candidates need to make sure that they read the question.

(iii) Most candidates could answer this question and had clearly learned the colours of the required indicators in acidic and alkaline conditions. However, there were some that did not know the correct colour or got the colours mixed up.

(d) (i) This was the first of two questions on electrolysis. This part was answered much better than the second part. Some candidates could label 'the cathode' but sometimes struggled to put a correct label at a correct position. The piece of apparatus needed to be labelled with a concise arrow and not just the name written by the side of it, as it is not clear where the candidate is meaning. The cathode is not the wire or the negative sign at the power supply. The label must point to the rod. An arrow should be used for clarity. More candidates labelled 'the electrolyte' correctly but again a concise arrow should be used. This should not point to the beaker but to the liquid in the beaker.

(ii) This second electrolysis question was answered poorly by many candidates, showing a lack of knowledge of the products and observations at the electrodes for 'molten lead(II) bromide using graphite electrodes'. Few candidates could say that 'bromine' was the product at the 'positive electrode' and 'lead' was the product at the negative electrode. Candidates could then not go on to state the observations at each electrode and few correct answers were seen.

(iii) Candidates answered this question really well and many could 'state one property of graphite that makes it useful as an electrode'. The correct answer was that it 'conducts electricity' or it is 'inert' or 'unreactive'.

Question 5

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Candidates found this question about metals reasonably straight forward. Many could 'Give one reason why stainless steel is used to make cutlery' as in **(b)** and could also 'put the four metals in order of their reactivity' as in **(c)**. Part **(d)** was also answered very well.

(a) Candidates answered this question reasonably well, showing much knowledge and understanding. Most candidates could write down at least one correct answer for 'State two differences in the physical properties of nickel compared to sodium'. Some candidates gave more than two answers when only two were asked for. This should be avoided as an incorrect answer could contradict a previously correct one.

(b) Most candidates answered this question very well and could 'Give one reason why stainless steel is used to make cutlery'.

(c) Some candidates got 'nickel' and 'lanthanum' in the wrong order. Others thought that 'metal' was one of the answers.

(d) Most candidates could 'complete the diagram to show the electronic configuration of a magnesium atom', which showed revision and practice of this key skill. Few wrong answers were seen.

Question 6

Candidates found some of this question challenging. They struggled with comparing the 'time taken' for reactions in **(a)(ii)** and **(a)(iii)** and the experimental question in **(b)**, showing that more practice is needed on these experimental type questions. Candidates were not confident with the solubility rules in **(c)**.

(a) (i) This was answered exceptionally well and most candidates could match the 'time taken for the reaction to finish' to the 'temperature' given.

(ii) Candidates struggled with this question which was asking for the 'time taken' instead of the 'rate of reaction'. Many candidates went on to read the question incorrectly and referred to 'rate' becoming 'faster' instead of 'less time taken' or 'takes a shorter time'.

(iii) Candidates mistook this question for asking about the 'rate of reaction' instead of the 'time taken'. Candidates wrote down that the 'rate decreases' or the reaction was 'slower' instead of that it 'takes a longer time' or 'more time is taken'.

(b) Many candidates struggled with this experimental based question and did not know the correct answer of 'filter off the excess magnesium' and 'heat until point of crystallisation' or 'heat until it forms a saturated solution'. Other incorrect separation techniques were seen. For example, 'fractional distillation'. Many candidates also wrote about 'evaporating off all of the water' or 'boiling off all of the water', which would not give crystals of magnesium chloride in this experiment. More practice of applying the different separation techniques to different practical scenarios is needed.

(c) This was a solubility rules question where candidates had to identify which one out of four given compounds was soluble in water. In order to answer this question, candidates needed to know the solubility rules; many candidates did not.

Question 7

Candidates struggled on this question especially on **(a)(iii)**, **(b)(i), (d)** and **(e)**. They did better on **(a)(ii)** and **(c)**. Most candidates could 'Deduce a molecular formula of an organic compound' and 'Calculate the relative molecular mass' but struggled with distinguishing a 'functional group that makes the organic compound unsaturated' and 'completing the word equation for the reaction of ethanoic acid with sodium'.

(a) (i) Candidates found this question very hard and few could 'Draw a circle around the functional group that makes compound **E** unsaturated'. Many drew the circle around the OH functional group, which was wrong. Some candidates also wrongly drew part of the circle around the carbon that was next to the carbon-carbon double bond as well as the double bond itself, which was also incorrect. More practice of identifying organic groups from displayed formulae is needed.

(ii) Many candidates had obviously practiced deducing the molecular formula of an organic compound. The elements can be placed in any order, but the numbers must be subscript and not superscript.

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(iii) Most of the candidates struggled with this chemical test question. Few knew that the answer was 'bromine water' and the colour change was 'remains orange' or 'no colour change' for a 'saturated' compound and 'turns colourless' or 'decolourises' for an 'unsaturated' compound. Some thought that the test was using 'bromide water' and many got the test mixed up with other chemical tests from other parts in the syllabus. More revision of the chemical tests stated in the syllabus is needed.

b) (i) Candidates found this question on the 'general formula for the alcohol homologous series' very hard and many did not know what the correct answer was. Candidates found this the most challenging question on the paper. Some wrote down the general formula for an 'alkane' or an 'alkene'. Many just wrote down a name of an alcohol like 'ethanol'.

(ii) Some candidates could 'Draw the displayed formula of ethanol. However, many candidates put extra hydrogens in or forgot the alcohol functional group, which made their answer incorrect. Many candidates forgot to put the covalent bond in between the oxygen and hydrogen in the alcohol functional group. It would be beneficial if candidates did more practice on drawing out the organic structures listed in this syllabus.

(c) Candidates did extremely well on this question, showing that the calculating of relative molecular masses of different compounds had definitely been practiced a lot in their revision. Most candidates could calculate the correct answer of '116' and few incorrect answers were seen here.

(d) Candidates struggled with this. Few correct answers were seen. Most candidates could not quote a correct temperature in the required range and also forgot that 'yeast' or 'absence of oxygen/ anaerobic' can also be used as a condition. Candidates must also be careful when quoting a range of temperatures. The highest and lowest values in their range must be included in the correct range.

(e) Most candidates struggled with this and many wrongly thought it was 'sodium hydroxide' and not the correct 'sodium ethanoate'. Few candidates could also state what the other product of this word equation was and many wrongly thought it was 'water' instead of 'hydrogen'.

Question 8

Candidates performed well on **(c)(i), (iii)**, **(iv)** and **(v)**. Part **(b)** was one of the questions on this paper that candidates struggled with the most, showing more work needs to be carried out on the environmental chemistry topics listed in this particular syllabus. Candidates struggled with **(c)(ii)** on 'State two properties of simple molecular compounds'.

(a) In most cases, this was a reasonably well answered question. Most candidates could at least provide one of the two required 'physical properties' for this question part. Some candidates got mixed up with what a 'physical property' was and referred to 'chemical properties' like inertness. Candidates must not state generally 'non-conductor'. They must say what it is a non-conductor of and in this question, it was 'electricity' as 'thermal' was already mentioned in the question stem so could not be used. Other candidates wrongly wrote down names of non-metals.

(b) Candidates performed poorly on this question. Very few candidates could 'State two strategies which help to reduce climate change caused by carbon dioxide'. Few candidates could state at least one method. This environmental chemistry topic needs to be concentrated on when both teaching it for the first time and in subsequent revision lessons afterwards.

(c) (i) This dot-and-cross question was a well answered question. Most of the wrong answers happened when candidates put extra electrons on the hydrogen atoms or forgot that there were 'four non-bonding electrons on the given oxygen atom'.

(ii) Candidates struggled with this. Many candidates could not state at least one of the 'properties of simple molecular compounds'. More revision is needed by candidates on this particular topic.

(iii) Candidates did very well on this question about definitions and could 'State the meaning of the term solvent' very easily.

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(iv) Candidates did exceptionally well on this question, and most were able to circle 'the pH value that is neutral'.

(v) The 'kinetic particle theory' question was the last question on this paper. The main mistakes were forgetting to be specific and talk about 'molecules' or 'particles'. Some candidates wrote down that 'molecules spread from a low concentration to a high concentration' which is incorrect.

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Paper 0620/41
Paper 4 Theory (Extended)

Key messages

- When writing formulae:
  - superscripts in ions should be written above the symbol and smaller than the symbol e.g. Pb^{2+} as opposed to Pb2+
  - subscripts should be written below the line and smaller than the symbol e.g. H_2O as opposed to H2O
  - lowercase letters should be smaller than upper case letters e.g. Na_2O as opposed to Na_2O.
- Candidates should understand the following regarding precipitation reactions:
  - how to use information concerning solubility rules to deduce which two aqueous solutions can be used to form a precipitate
  - how to write ionic equations (including state symbols) for precipitation reactions
  - practical details of how to separate and purify an insoluble solid formed in a precipitation reaction
- If a question asks for a name, it is inappropriate to give a formula or an equation.
- If a question asks for a formula, it is inappropriate to give an equation or a name.

Comments on specific questions

Question 1

(a) This equation was recognised by a minority of candidates.

(b) This was answered correctly by only a small number of candidates. Equation **I** was a common wrong answer.

(c) This was answered correctly by a large number of candidates.

(d) This was answered correctly by a large number of candidates.

(e) This was answered reasonably well.

(f) This was answered correctly by a large number of candidates.

Question 2

(a) (i) This was answered correctly by a large number of candidates. ‘O’ was seen occasionally as the answer.

(ii) This was answered correctly by a large number of candidates. ‘Li’ was a common wrong answer.

(iii) This was answered correctly by a large number of candidates. ‘Be’ was a common wrong answer

(iv) This was answered correctly by a large number of candidates.

(v) This was answered correctly by a large number of candidates.

(vi) This was answered reasonably well. ‘O’ was seen most often as an incorrect answer.

(b) (i) Many candidates omitted a reference to atoms. Statements about the same number of protons and different numbers of neutrons were often correct.

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(ii) There were many good answers to this calculation. Most candidates gave their answer to one decimal place as requested. The most common error was to add 10 and 11 and divide by 2 giving an answer of 10.5. A small number of candidates rounded up to 11 or 11.0. It is important that candidates show all working out in calculations.

Question 3

(a) (i) The most common error was to show only 7 electrons in the outer shell of the oxide ions. This was presumably because candidates were unaware that **two** sodium atoms donated one electron each to the oxygen atom.

(ii) This was answered reasonably well. Some gave an equation instead of a formula. Candidates should be aware that a formula begins with a symbol as opposed to a number.

(b) This was answered reasonably well. The majority of candidates showed two pairs of bonding electrons in both bonds. Common errors included too many non-bonding electrons on the oxygen atoms and non-bonding electrons on the carbon atom. These problems were caused because candidates were unaware that the number of electrons available was different to four from the carbon atom and six from each oxygen atom.

(c) (i) Many candidates referred to ionic bonding and then went on to contradict themselves by reference to atoms or molecules. Some referred to strong forces instead of strong forces of attraction.

There was no requirement to compare sodium oxide with carbon dioxide. Many candidates misread the question in this respect.

(ii) Covalent bonding was seen just as often as the correct answer.

Question 4

(a) The vast majority of candidates stated that catalysts increase the rate of a reaction. A statement that catalysts are not used up was common. This means that there is some catalyst remaining at the end. However, all the catalyst remains unchanged at the end of the reaction. This needed to be stated. Lowering activation energy was also occasionally seen, which gained credit.

(b) (i) Candidates should realise that the decrease in mass can only be due to matter leaving or escaping from the apparatus. In this case, the gas in question was gaseous oxygen. 'Oxygen being given off or produced' was insufficient to gain credit. The gaseous product was sometimes thought to be hydrogen.

(ii) Rate of reaction depends on concentration as opposed to mass or volume or amount, all of which were frequently seen. The reaction is fastest at the start of the reaction because the concentration of hydrogen peroxide is at its highest at the start.

(iii) The majority of candidates omitted to mention that the rate of reaction becomes zero because all the hydrogen peroxide is used up. It was fairly common to see statements that the amount of catalyst had decreased.

(c) Many candidates stated that particles gained kinetic energy and moved faster. Candidates sometimes mentioned an increased number of collisions as opposed to an increased collision frequency. Only a few candidates referred to activation energy. Those that did, often made partially correct or wholly incorrect statements.

Other common errors seen were: not mentioning particles anywhere in the response; describing 'more collisions' or 'increased chance of collisions' rather than increased collision frequency.

(d) This calculation was answered reasonably well. A common error was to multiply the number of moles of O_2 by either 24 or 16 instead of 32.

(e) A catalyst increases the rate of a reaction without having any effect on the amount of substance produced. The mass of oxygen produced in this reaction depends totally on the amount of hydrogen peroxide used. Changing the mass of catalyst has no effect.

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(f) Candidates performed poorly on this question. The formula of mercury(II) oxide was often incorrect, despite it being given. The formula of oxygen was often written as O. Hg_2 was also seen.

The equation was sometimes unbalanced even if the formulae were all correct. Some attempted to write the reactants as products and vice versa.

Question 5

(a) (i) Many candidates repeated the definition of electrolysis that they had learned. Those who used different terminology often produced incomplete or misleading statements.

(ii) Many stated that graphite was inert or a conductor of electricity. Very few made both statements that were required.

(iii) This was answered reasonably well. Common errors included the wrong charge on the hydrogen ion and the formula of hydrogen written as H.

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

(v) This was answered less well. Electron and proton were the most common incorrect answers.

(vi) The syllabus makes a distinction between dilute and concentrated aqueous halide solutions as electrolytes. Therefore oxygen, as opposed to bromine, is the anode product when the electrolyte is dilute aqueous potassium bromide.

Potassium was occasionally seen as the cathode product.

(b) (i) This was answered reasonably well. There were no common incorrect answers.

(ii) Incorrect statements about melting points were common. The melting point of aluminium oxide is fixed and cannot be changed by the use of cryolite. Answers that referred to boiling point similarly went uncredited.

Cryolite as a catalyst was commonly seen. The function of cryolite as a solvent was rarely mentioned. There were many references to cryolite as an electrical conductor itself rather than stating that cryolite increased the conductivity of the electrolyte.

(iii) The conversion of the carbon anode to carbon dioxide was only mentioned by a minority of candidates.

(c) (i) A minority of candidates were aware that the equation for the reaction in a hydrogen–oxygen fuel cell is the same as that for the combustion of hydrogen in oxygen. H and O were often seen as incorrect formulae. H_2O was only seen occasionally as the product.

(ii) Most answers were vague and non-specific, such as:
- no pollution
- not environmentally friendly
- no toxic products
- renewable, without reference to oxygen or hydrogen.

The correct answer needed to refer specifically to the hydrogen–oxygen fuel cell and its comparison with petrol in vehicle engines.

Question 6

(a) (i) The equation was balanced by a majority of candidates. '7' was occasionally seen in front of O_2. In some cases, crossings out made candidate responses difficult to read.

(ii) There were many misunderstandings regarding this question. Some merely gave the oxidation number of iron without naming the compound. Iron(II) oxide was commonly seen as was iron(III) trioxide.

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(b) (i) Candidates answered this question reasonably well. Some suggested that enzyme denaturation was the reason for not using a greater temperature. One error was to refer to the 'exothermic side'.

(ii) Candidates found this somewhat less challenging than **(b)(i)**. One error was to refer to the reaction with fewer molecules.

(c) Only a small number of candidates were able to write the correct formula of ammonium sulfate. Others gave additional products, namely H_2 or H_2O.

(d) (i) Only a small percentage of candidates knew that all nitrates are soluble in water.

(ii) This was poorly answered.

Ionic equations for precipitation reactions should include the aqueous ions on the left-hand side and the solid precipitate on the right. The formula of lead(II) sulfate was often wrong, either Pb_2SO_4 or $Pb(SO_4)_2$. Many equations included other species.

(iii) Those who correctly started with filtration then went on to describe crystallisation of the aqueous filtrate instead of purification of the residue. Those who decided to wash and dry the residue often omitted sufficient detail of how to do this to obtain any credit.

Question 7

(a) (i) This was answered quite well. Some candidates focused on the substitution reaction rather than the need for ultraviolet light.

(ii) This was answered reasonably well. Common errors were to include branched chain isomers or to draw the same isomer twice.

(b) (i) Attempts at structural formulae or names instead of molecular formulae were quite common.

(ii) This was answered very well. Spelling 'carboxylic' was often challenging.

(iii) Answers were often descriptions other than observations, as well as incorrect observations, the most common of which was a 'precipitate forming'.

(iv) This was answered reasonably well. There was no requirement for brackets or –n when drawing a repeat unit. Many answers contained carbon–carbon double bonds. Connectivity issues involving the two carbon atoms in the main polymer chain being bonded to –COOH and $–CH_2OH$.

(v) Candidates found this challenging. Common answers included esters and named polymers such as Terylene, PET and polyamides.

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Paper 0620/42
Paper 4 Theory (Extended)

Key messages

- Where candidates are required to select an answer from a set of possible choices, such as **Question 1**, then they should be encouraged to make sensible guesses rather than leaving an answer blank. There is no penalty for an incorrect attempt.
- Candidates should not provide fractions as answers to calculations such as **Question 4(g)**.
- In extended questions such **Question 3 (b)(v)**, candidates are advised to present their answers in short, concise sentences. The use of bullet points helps to prevent long, rambling sentences which tend to lead to repetition of some facts and often show contradictions to earlier correct answers.

General comments

The overall standard was very high, but this was the first June examination following a syllabus update and it was noticeable that some candidates were not familiar with the newer content of the syllabus.

Candidates need to be careful in the use of subscripts in formulae and upper/lower case in symbols.

If a single answer is asked for, two or three answers should not be given, as incorrect statements may contradict correct answers. There were many incidences of candidates giving more than one answer where only one was required and thus not gaining credit.

Comments on specific questions

Question 1

This question required choices from eight metal oxides given in the question.

Most candidates performed well overall with **(a)**, **(b)** and **(d)** usually being correct.

Parts **(c)** and **(f)** proved more difficult and **(e)** was the hardest, with only about one-third of the candidates getting this correct because the majority assumed iron(III) oxide was the main impurity of iron ore.

Question 2

(a) Most candidates correctly named elements in Group VII as 'halogens' with 'halide' being the most common error.

(b) A significant number of candidates omitted the word 'number' and wrote 'same electron' in the outermost shell'. This did not get credit.

Although not incorrect, many candidates referred to the outermost shell electrons as 'valence shell electrons' – a term that has not been used in this syllabus for many years.

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(c) The colours and states of the halogens are now given in the syllabus. Chlorine was expected to be pale yellow-green in colour and bromine to be red-brown. Candidates who performed less well assumed elemental bromine to be orange, probably because of confusion with bromine water.

(d) (i) The term nucleon number or its alternative, mass number, was not well known.

(ii) The majority of candidates who performed well gained three marks. Occasionally, the neutron row was seen as 79 and 81.

(iii) Most candidates realised that isotopic mass × abundance was significant. These candidates were able to determine the average of this value to one decimal place. A significant number then changed their answer from 79.9 in the working to 80 or 80.0 on the answer line.

(e) (i) Most candidates worked out that KCl was formed but many made errors in the rest of the equation such as Br instead of Br_2 for bromine.

(ii) Most realised the reaction did not happen because chlorine was less reactive than fluorine.

(f) (i) The formation of a white precipitate was known by most. Some candidates incorrectly described effervescence.

(ii) A significant number of candidates wrote symbol equations rather than ionic equations. Of those who attempted ionic equations, some left spectator ions in their final answer.

Many candidates made various attempts as part of their working, both above and below the answer line, but a significant number did not cross through unwanted material on the answer line giving rise to an incorrect answer as well as the correct answer.

Question 3

(a) The name of the Contact process was quite well known, with only a few opting for the Haber process.

(b) (i) This question relied upon knowledge of the new syllabus in LO 6.3.9. Neither burning sulfur or roasting sulfide ores was well known.

(ii) Some candidates were able to describe equilibria; others needed to take care with wording.

Vague statements such as, ‘the forward reaction equals the reverse reaction’ were seen, which has no reference to *rate* of these reactions. ‘Concentrations of products and reactants are the same’ was also too vague. Better responses stated, ‘concentrations of products and reactants *stay* the same’.

(iii) The temperature and identity of the catalyst were well known, but the value of the pressure in kPa, less so. The conditions given in LO 6.3.10 of the syllabus were expected. ‘2 kPa’ was a frequent error. The oxidation state of vanadium in the catalyst was often incorrect.

(iv) Most candidates coped well with predicting effect of changing the conditions.

(v) Some candidates were able to explain why changing the temperature changes the rate of reaction. Most knew the energy decreases and could state the frequency of collisions decreases – often seen as ‘less collisions per unit time’. Candidates who performed less well tended to simply state there were ‘less collisions’ without reference to frequency. Few candidates appreciated that a lower percentage of particles have energy greater than activation energy. However, many candidates wrote phrases such as ‘particles have energy lower than activation energy’, suggesting all particles had energy lower than activation energy.

Some candidates erroneously stated activation energy is changed.

(c) Many candidates found this question very challenging and were clearly unfamiliar with the method needed to solve the problem. Candidates need to be aware that a key part of an oxidation number is the positive or negative sign preceding the integer. Integers alone are not oxidation numbers.

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Question 4

(a) Most candidates knew that a base was a proton acceptor. Phrases about neutralizing acids or pH values were ignored.

(b) Most candidates knew that a soluble base is known as an alkali.

(c) The colour of thymolphthalein in alkali was well known.

(d) The names of the products of this word equation were well known. Sodium chloride was almost universally known. Occasionally, 'ammonia' was incorrectly written as 'ammonium' and 'hydrogen' frequently appeared instead of 'water'.

(e) (i) Candidates performed poorly on this question and a very common incorrect answer was 'acidic'. Better performing candidates were able to work out that the correct term was 'amphoteric'.

(ii) Although candidates may not have been correct in their answer to **(e)(i)**, many named one of the two examples of amphoteric oxides given in the syllabus.

(f) (i) The dot-and-cross diagram of ethanoic was done well by candidates who performed well, with each covalent bond being represented by a dot and cross. Although not necessary, some candidates felt the need to introduce a third symbol for electrons belonging to hydrogen atoms. Candidates who used a pair of the same symbols for a covalent bond did not receive full credit.

Candidates who performed less well did not show the non-bonding electrons on both oxygen atoms. Some of these candidates were able to gain credit for the single dot and cross bonds or the dot and cross double bond.

(ii) Nearly all candidates gave a pH within the acceptable range. It should be noted that an answer such as $pH \leq 7$ would not get credit because the pH could not equal 7 and the pH of a strong acid, e.g. 2, fits this expression.

(iii) Only the better performing candidates gained full credit. The most common error was to use a one directional arrow instead of the reversible arrows.

Weaker responses were able to gain credit for a single H^+ ion as a product. Many incorrectly gave $4H^+$ as a product, suggesting that all hydrogen atoms in CH_3COOH ionised. Very few of these responses gave the CH_3COO^- anion formed.

(iv) Only the better performing candidates could recall this new part of the new syllabus from LO 7.1.8.

(g) A wide range of marks was seen here with the better performing candidates gaining full credit.

Candidates should be reminded that fractions as answers to calculations will not receive credit in this chemistry exam. Candidates should also be reminded that leaving the M_r calculation as a sum such as $2 + 32 + 64$ may also not receive full credit.

Question 5

(a)(i)(iv) These questions were based upon LO 11.4.4 of the new syllabus.

Most candidates performed well with **(i)** and **(iii)** and substitution and photochemical were seen frequently. In **(ii)**, the idea of ultraviolet light providing the activation energy needed for the reaction was not known.

In **(iv)**, some candidates opted for 'disubstitution', despite the wording of the question.

(b) (i) Many responses were too vague. It was important that a candidate referred to carbon–carbon bonds in their answer. An answer such as, 'here is a carbon double bond' is insufficient as the double bond could be to another atom such as oxygen in carboxylic acids.

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(ii) Better performing candidates tended to give the correct structural formula of 1,2-dichloropropane. Many gave either 1,3-dichloropropane or 1,1-dichloropropane as incorrect answers. Other candidates gave ambiguous formulae such as $C_3H_6Cl_2$.

(c) Of the candidates who knew the answer, the correct name of propan-2-ol was frequently given but the same candidates referred to propan-1-ol as 'propanol'. Others were unaware of the IUPAC system of naming alcohols with more than two carbon atoms.

Many of these candidates drew the displayed formulae incorrectly because of omitting the O–H bond.

Question 6

(a) The name of the ester was known by most candidates. The most common error was the misspelling of 'butanoate' as 'butanote'.

(b) The identity of water as the product in an esterification reaction was well known, but various incorrect answers such as 'hydrogen' or the names of other esters were seen.

(c) Most candidates were unable to deduce the empirical formula of the ester with many simply stating the molecular formula rather than recognising the need to cancel this down to the simplest whole number ratio.

(d) (i) Candidates who chose to circle a repeat unit, starting at one of the ends of the given structure, tended to be more successful than those who circled a unit in the middle. Some candidates simply circled the ester linkage.

(ii) A wide range of responses was seen here. Many candidates did not appreciate that monomers do not have continuation bonds and are discrete molecules.

Other frequently seen errors included connecting the O–H bonds to the box via the hydrogen atom, thus creating divalent H atoms or transposing correctly drawn groups to the wrong box.

(iii) Most candidates recognised this as condensation polymerisation.

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Paper 0620/43
Paper 4 Theory (Extended)

Key messages

- Where candidates are required to select an answer from a set of possible choices, such as **Question 1** and **Question 2(a) to (vi)**, they should be encouraged to make sensible guesses rather than leaving an answer blank.
- When a question asks for an explanation in terms of collision theory, candidates should ensure that answers are expressed in terms of particles and include the effect on the collision frequency of the particles.
- When a question asks for an explanation for a high melting point of a compound in terms of structure and bonding, candidates should ensure that details of the structure of the compound are included in their answer, for example giant covalent structure.
- Candidates should understand what the word 'observation' means and how to answer questions that ask for observations. This might include:
  - a solid dissolving or disappearing or ceasing to do so when a reaction has ended
  - effervescence when a gas is evolved or cessation of effervescence when a reaction has ended
  - the formation of a precipitate with its colour, when an insoluble solid is produced from the mixing of two solutions
  - candidates would benefit from practice at drawing the structure of the repeat unit of an addition polymer, given a named alkene monomer
  - candidates would benefit from practice at deducing and drawing the structures of diol and dicarboxylic acid monomers used to produce unfamiliar condensation polymers.

General comments

- If extra pages are used, the questions must be clearly numbered and candidates should ensure that extra answers do not contradict those on the answer line.
- Some candidates made multiple alterations to answers rather than crossing out and rewriting them clearly. This was particularly evident for equations. This often made their answers difficult or impossible to read.

Comments on specific questions

Question 1

Many candidates found it challenging to identify the correct equation from the list. Some candidates wrote the equation rather than simply writing the required letter. Only one letter was required for each question, however, many candidates gave multiple contradictory answers and thus gained no credit.

(a) The photosynthesis equation was generally well known by many candidates.

(b) This was not well known. The most common incorrect answers were **A**, the neutralisation equation, and **I**, the combustion of hydrogen equation.

(c) This part proved the most difficult of **Question 1** and only a small minority of candidates were able to recognise the precipitation reaction equation. A wide variety of incorrect answers were seen.

(d) The incomplete combustion equation was well-recognised by many candidates.

(e) This was not well known. The substitution equation, **C**, was the most common incorrect answer.

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(f) This was not well known. The displacement equation, **F**, was the most common incorrect answer. The frequent transposing of the displacement and substitution reaction equations by candidates demonstrated widespread confusion between the two types of reaction.

Question 2

(a) (i) Aluminium was generally well known, although some candidates incorrectly chose magnesium or sodium.

(ii) This was answered reasonably well.

(iii) This was very well answered, although sodium, sulfur and phosphorus were commonly seen.

(iv) This was less well answered, with many candidates obviously unfamiliar with the term amphoteric oxide. The most common incorrect answers seen were sodium, magnesium, and silicon.

(v) This was quite well answered but chlorine, silicon and phosphorus were frequently seen incorrect answers.

(vi) Candidates performed poorly on this question. The incorrect answers most commonly seen were sulfur, sodium and magnesium.

(b) (i) Many candidates had the idea that carbon was required but chose ^{14}C or just carbon. Hydrogen and sodium were also frequently seen incorrect answers.

(ii) Many of the better performing candidates were clearly familiar with the calculation of relative atomic mass and were able to gain full credit. However, many candidates who performed less well did not attempt the question or found it very challenging and did not seem to know where to begin. Candidates should be encouraged to show all their working out and not to just write their final calculated answer due to the possibility of errors being made and thus no credit being gained for the use of a correct method.

The most common errors seen were: averaging of the two relative masses 24 and 25 to gain 25 without using the percentage abundances; answers of 24 seen without working out (perhaps using the mass number of magnesium given in the Periodic Table); correctly calculated answers of 24.3 then incorrectly rounded to a final answer of 24 due to lack of understanding of the requirements of one decimal place; calculations where an attempt had been made to use all of the figures available but division rather than multiplication by the percentage abundances had been carried out, for example $\frac{24}{85} + \frac{26}{15} \times 100$.

(c) (i) This was quite well answered, however, 14 was a common incorrect answer, suggesting that many candidates did not understand the difference between the number of neutrons and the nucleon number. The number of protons, 13, was also given, but less frequently.

(ii) This was well answered. Cobalt, which has atomic number 27, rather than mass number, was the only commonly seen incorrect answer.

Question 3

(a) (i) Many candidates were confused by the fact that this ionic bonding question was asked in an unfamiliar way, with the electronic configuration of only one fluoride ion required rather than two. The charge was frequently correct. The most common errors seen were: drawing the electronic configurations of the magnesium and fluorine atoms rather than the ions; showing the fluoride ion as having all dots in the outer shell instead of seven dots and one cross; drawing an extra third shell on the fluoride ion.

(ii) This was generally well answered and many candidates who gave the incorrect charge of 1+ for the magnesium ion **(a)(i)** were able to deduce the correct formula of MgF_2 here from previous knowledge. The most common errors seen were: leaving charges in the formula; word equations or sentences instead of formulae; using the symbol F*l* for fluorine in the formula.

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(iii) This was quite well answered, although some candidates did not gain credit as their answers were incomplete and described heating the magnesium fluoride with no mention made of melting it. Some candidates did not read the question and suggested dissolving. Electrolysis was another commonly seen incorrect answer.

(b) This was quite well answered with most candidates following the instructions and using both dots and crosses to represent the electrons of the two different atoms. The most common error was to show too many or too few non-bonding electrons on one or more of the chlorine atoms. Most candidates paired the non-bonding electrons and this is good practice as it is easier to self-check that atoms have a complete octet. Those opting to draw individual non-bonding electrons were more likely to draw too many or too few on one of the four chlorine atoms.

(c) (i) Candidates found this question challenging and only a very small proportion knew that the particles held together by weak forces of attraction were molecules. The most common incorrect answers seen were: atoms; ions; intermolecular forces; electrons.

(ii) The question asked for an explanation of the high melting point of silicon(IV) oxide in terms of both the structure and bonding. Better performing candidates identified the bonding as covalent, described the bonding as strong and correctly identified the type of structure as giant or macromolecular. Other candidates were only able to write that the bonding was covalent and that it was strong. Candidates should be encouraged to read the question carefully and to make sure that they are attempting to answer all aspects of it in order to gain full credit.

The most common errors seen were: not specifying the type of bonding, only that it was strong, which was sufficient to gain credit; covalent bonding named but contradicted by intermolecular bonding elsewhere in the response; ionic bonding given; double covalent bonding given; the structure described as large or a lattice but not giant; repeating the question about a high temperature being needed to break bonds rather than that bonds are strong or require a lot of energy or heat to break them.

Question 4

It was obvious from the answers given in **(a)(i)** and **(a)(ii)** that the majority of candidates had not read the question properly and thus did not appreciate that the zinc was in excess and that it was the sulfuric acid that was the limiting reagent in the reaction.

(a) (i) Only the better performing candidates were able to identify that the reaction rate decreased due to either decreasing concentration of sulfuric acid particles or decreasing frequency of collisions between particles. The decrease in collision frequency was the less frequently stated. Some candidates were on the right track with ‘less acid particles’ but this is insufficient on its own as it lacks the idea of less particles per unit volume or particles being less crowded. Also, the idea of less collisions was often seen but is similarly insufficient without the frequency element. Candidates who performed less well tended to write about the reactants or acid being used up or the zinc having all dissolved or having all been used up. Candidates should be reminded that answers describing ‘less chance of collisions’ are not creditworthy.

(ii) This proved to be one of the most difficult questions on the paper. Belief that the zinc had all reacted was the most common reason that candidates incorrectly gave. Some candidates wrote that all the reactants had been used up which was not specific enough to gain credit.

(b) Many candidates realised that powdered zinc has a larger surface area than lumps. However, only a minority of candidates appreciated that the question asked for an explanation in terms of collision theory and that this required particles (or the equivalent term, for example atoms or molecules) and collision theory to be mentioned in the answer. Some candidates did write about collision frequency but omitted to mention that it was particles colliding and thus did not gain credit. Many answers went no further with their explanations. Other commonly seen errors were: the idea that powdered zinc dissolves more easily than lumps or is easier to breakdown; more chance of collisions.

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(c) Candidates who performed less well often struggled to achieve any credit and seemingly did not know how to approach the calculation. Random guess figures without any working out were often seen as answers.

Many candidates were unsuccessful in calculating the number of moles of acid used. Common errors seen in the first step were: attempting to use the M_r of sulfuric acid in the calculation; not converting the volume of the acid from cm^3 to dm^3, for example $2.00 \div 25.0$ or $\frac{25.0}{2.00}$. In the second step, the most common error was to divide the number of moles of acid by two to get the number of moles of hydrogen. This took no account of the stoichiometric coefficients given in this equation. Many candidates were able to multiply their calculated number of moles of hydrogen by the molar gas volume.

Candidates should be reminded that fractions as answers to calculations will not receive credit.

(d) (i) Many candidates did not know the correct formula for zinc chloride. It was commonly seen as $ZnCl$. Those candidates who knew the correct formula were very likely to be able to balance the equation successfully. The other most common errors seen were: giving hydrogen as the only product (zinc chloride was not given to the candidates in the question); the formula of hydrogen written as monatomic H or 2H; sulfuric acid instead of hydrochloric; zinc written as Zn_2.

(ii) This was reasonably well answered. Both the test and result were needed. The most commonly seen errors were: no description of the splint as being lighted; glowing splints showing confusion with the test for oxygen; the test described as 'splint test' or 'squeaky pop test' with no mention of a lighted splint. Candidates should be encouraged to learn the tests for common gases given in the syllabus.

Question 5

(a) (i) Many candidates were unsure of what was required in their definition. Details about electrolysis were given in the question and did not form part of the required answer. The best answers referred to an electrolyte as being an ionic compound in molten or aqueous form. Candidates commonly mentioned a liquid or solution. Far fewer candidates were able to identify that an ionic compound was used. Candidates who performed less well gave a poor description of electrolysis or referred to an electrolyte as a type of drink.

(ii) The fact that the Roman numeral was the oxidation number of copper was not well known and correlates with the poor candidate performance in **(a)(vi)**, suggesting oxidation numbers are not well-understood by candidates. Common errors were: 'it means 2'; 'the charge of copper'; 'the oxidation number of copper sulfate' or 'the oxidation number of the compound'; 'the valency of copper'.

(iii) This question was not well answered. Candidates commonly wrote that the colour turned blue or turned brown.

(iv) Candidates found this question challenging. Many candidates wrote the ionic half-equation for the oxidation of copper to form copper ions. Other common errors seen were: the incorrect charge on the copper ion; the electrons appearing as subtracted from the copper ion or added on the product side of the equation, denoting a loss of electrons by the copper ion i.e. $Cu^{2+} - 2e^- \rightarrow Cu$ or $Cu^{2+} \rightarrow Cu + 2e^-$

In addition, candidates need to be aware that although $Cu^{2+} + 2e^- \rightarrow Cu$ may be considered mathematically equivalent to $Cu^{2+} \rightarrow Cu - 2e^-$, the latter is not a correct chemical description of the changes taking place.

(v) Most candidates assumed that the ion forming oxygen would be oxide and thus gained no credit. A minority knew that the ion was OH^- and some correctly wrote the ionic half-equation for the formation of oxygen from hydroxide ions. The question asked for the formula of an ion so 'hydroxide' was not creditworthy and neither was 'H_2O'. Other common incorrect answers seen were: the SO_4^{2-} ion; word equations; compounds such as $CuSO_4$, rather than ions.

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(b) The majority of candidates gave a correct observation although the question did not specifically ask for one, recognising that the anode would dissolve or get smaller. Some of the better performing candidates wrote about oxidation of the anode. Correct oxidation equations were acceptable but were rarely seen. The most common errors were: giving observations for the cathode such as a coating of pink or brown metal or the electrode getting bigger; reduction of the anode.

(c) (i) Candidates found this challenging. Some candidates transposed the silver and spoon electrode positions. Graphite electrodes in combination with electrolytes given as molten silver or insoluble silver compounds such as silver chloride were common incorrect answers. Some candidates answered throughout as if answering an electroplating with copper question.

(ii) This was a well answered question with most candidates stating the improved appearance of the spoon. The most commonly seen incorrect answers focused on the fact that the spoon was a good conductor of electricity and showed a misunderstanding of the question.

(d) (i) Candidates should be encouraged to give the adverse effects of the common air pollutants as written in the new syllabus, which in this case is increased global warming for carbon dioxide and toxic gas for carbon monoxide. Many candidates gave very vague answers about pollution for either or both gases. Carbon monoxide was often given as a cause of acid rain. Some candidates did not appear to understand the meaning of 'adverse' and gave uses or methods of production of both gases. Others gave unnecessarily detailed biological explanations for the adverse effects of carbon monoxide when only 'toxic' was required by the syllabus.

(ii) This question proved to be the most difficult on the paper. Most candidates struggled to give a sensible disadvantage for the use of hydrogen–oxygen fuel cells. Many did not read the question properly and gave an advantage instead. The best answers focused on the difficulties of storing or transporting hydrogen as it is a gas and must be stored under high pressure, or the lack of infrastructure or hydrogen filling stations needed to supply the hydrogen. Answers that described hydrogen as dangerous because it is highly flammable were not accepted as petrol is also highly flammable, neither were answers describing inefficiency as fuel cells are more efficient than using petrol.

Question 6

(a) (i) This was quite well answered, however there were some answers lacking in logic that suggested the nitrogen could come from ammonia, or simply writing N_2 from the equation given in the question. The process used to obtain the nitrogen from air was not required.

(ii) This question was less well answered. As per the syllabus, methane or natural gas were the only acceptable answers. Processes were not required, and combustion of methane was rejected as it would not yield any hydrogen. Some candidates believed that it would make sense to source the hydrogen from ammonia itself. Other common incorrect responses seen were: water; air; hydrocarbons; $3H_2$ from the equation given.

(iii) Candidates should be encouraged to learn the temperatures, pressures and catalysts given in the new syllabus for both the Haber process and the Contact process. Many candidates gave a temperature outside of the acceptable range. Some gave the pressure associated with the Contact process. A large number of candidates gave the temperature of 900 °C and the pressure of 7 atmospheres, which were conditions given in **(b)(i)** for the reaction to produce nitrogen monoxide.

(iv) This was designed as a simple recall question but many candidates did not know the catalyst and could not make a sensible guess. Vanadium(V) oxide was the most common incorrect answer.

(v) Most candidates knew that catalysts increase the rate of reaction. Many went on to state 'catalysts are not used up', which means that there is some remaining but not necessarily that it is unchanged. Another common error was to write that 'catalysts do not take part in the reaction'. Candidates should be encouraged to learn the definition of a catalyst as given in the syllabus.

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(b) (i) Candidates found this question very challenging and struggled with why a given temperature and pressure were **not** used, rather than what happens when a temperature or pressure is changed. Candidates were able to answer each part of the question in two possible ways: what would happen if the new condition was applied to the reaction, or why the original condition should still be used instead. Candidates were more likely to opt for the former way in both parts. Unfortunately, the language used by some candidates made it very unclear which approach they were trying to use.

For the temperature change, common errors were to write about shifts in the equilibrium in the wrong direction or to suggest that an equilibrium shift to the right would give a lower yield. Many candidates wrote that the reaction would not occur at all at a lower temperature or that it would be dangerous. Many were very confused about the difference between rate and equilibrium shift.

For the pressure change, credit was also given for safety concerns with the use of high pressure. Common errors were to describe a decrease in the rate of the reaction or to contradict a correct direction of equilibrium shift to the left with a further comment that the reactants had more moles.

(ii) Although generally well done, candidates often had multiple attempts to balance this equation, with repeated crossings out. The result was often illegible if not clearly written out again and some candidates consequently did not gain credit.

(c) (i) Knowing or being able to work out the formula of copper(II) nitrate proved too difficult for most candidates. Many did not know the formula or charge of the nitrate ion. The formula of copper(II) carbonate was also often incorrect. Candidates who performed less well did not know the formula of nitric acid either. Many knew that water and carbon dioxide would be among the products but could not gain credit for this.

(ii) This was poorly answered. The question asked for two observations to indicate that the copper(II) carbonate was in excess. This required candidates to therefore consider what visible evidence there would be that the acid had been used up and the reaction was over. The only two acceptable observations were that the solid would stop dissolving and that effervescence or bubbling would no longer occur when more copper(II) carbonate was added. 'No more gas produced' and 'the reaction stops' are not observations. A solid seen building up should not be described as a precipitate in this case as this is not the correct use of the term. Many candidates wrote that there would be bubbling, rather than the fact that bubbling would stop. Candidates that performed less well simply repeated the wording from the question stem about copper(II) carbonate being in excess, rather than giving an observation.

(iii) The expected answers of copper(II) oxide or copper(II) hydroxide were commonly seen. However, the most popular answer was copper(II) sulfate, which is incorrect as it would not react to produce copper(II) nitrate.

Question 7

(a) (i) This was quite well answered, with most candidates realising that ultraviolet light or sunlight would be required for this reaction. However, candidates who performed less well wrote only about the temperature or pressure requirements.

(ii) This question was well answered and only a minority of candidates were not able to draw the displayed formula of at least one isomer. Structural formulae were not often seen. Candidates should be reminded that if a question asks for a displayed formula, then **all** of the bonds present must be shown and it is not acceptable to show methyl groups as $–CH_3$. Many candidates drew the same isomer twice, usually 1-chloropropane, with the second structure as a mirror image of the first or with a bend in the carbon chain, obviously thinking that this was a different isomer. Candidates should be taught that in the case of a monosubstitution, a chlorine atom drawn on either end of the molecule is the same isomer.

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(b) (i) The definition and characteristics of a homologous series were not well answered. The most common correct answers given were either the same general formula, similar chemical properties or the same functional group. Those candidates choosing physical properties were often unable to offer creditworthy responses due to not mentioning trends or gradual changes. These candidates were more likely to write 'similar physical properties'. 'Similar functional group' was often seen, as was the idea of compounds 'belonging' to the same functional group. Better performing candidates were aware that the words 'same' and 'similar' have different meanings. Candidates should also be aware that 'similar reactivity' was not accepted as it does not mean the same thing as having similar chemical properties.

(ii) Most candidates found this question very challenging. Candidates should be reminded that addition polymers do not contain the double bonds between carbon atoms found in the alkene monomers they are made from, and that continuation bonds at both ends must be left to show that the repeat unit is part of a much bigger molecule. However, divalent hydrogen atoms must not be drawn. Candidates should practice drawing the addition polymers formed from a variety of alkene monomers.

(c) (i) This was designed to be a challenging question to test the understanding of condensation polymer formation, and this proved to be the case. Many candidates did not attempt this question or simply copied out sections of the polymer given in the question, complete with ester linkages. The question did not ask for displayed formulae and so structural or displayed formulae were both creditworthy. Many candidates did not appreciate that monomers do not have continuation bonds and are discrete molecules.

Other frequently seen errors were: omitting hydrogen atoms from the hydroxyl groups of both monomers; connecting hydroxyl groups or carboxyl groups to the rest of the molecule by the H atom and thus creating divalent hydrogen atoms i.e. –HO or –HOOC; monomers with a functional group at one end only, usually ethanol and propanoic acid.

Candidates should practice deducing and drawing the structure of monomers used to create polyesters, especially when the polyesters given in the question are without the more familiar boxes used to represent the alkyl chains.

(ii) Over a third of candidates did not make any attempt to answer this question. Many gave an example of a polyester, such as PET or Terylene, rather than the type of condensation polymer. Ester and nylon were other commonly seen incorrect answers.

(iii) Many candidates who had drawn uncreditworthy monomers in **(c)(i)** were still able to correctly name at least one of the homologous series. Dicarboxylic acids and dialcohols were also accepted as creditworthy answers. Many candidates incorrectly suggested alkenes or esters.

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Paper 0620/51
Paper 5 Practical Test

Key messages

- The Confidential Instructions state that the supervisor must do the experiments in **Questions 1** and **2** and record the results on a copy of the Question Paper. These results must then be included with the scripts from the centre when they are returned. Where the practical exam has taken place in more than one practical session or laboratory, it should be clear which set of supervisor's results are for which session or laboratory and also which candidates were in which session or laboratory.
- It is essential that centres make up solutions and provide apparatus in accordance with the details contained in the Confidential Instructions. If there is difficulty in obtaining some substances, then the centre should contact Cambridge for advice.
- Readings recorded from a given item of apparatus should all be recorded to the same resolution (the same number of decimal places).
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, an incorrect formula will contradict a correct name.
- In the qualitative analysis question (**Question 2**) where a question states, 'Test any gas produced', candidates are expected to test the gas and record the details for the gas test that gave a positive result. Candidates are expected to use the term 'precipitate' when describing the formation of a solid from the reaction between two solutions; if when two solutions are mixed the product becomes cloudy and opaque then a precipitate has been formed.
- In qualitative analysis, not all of the tests described will necessarily give a positive result; a negative test result is useful since it informs that a certain ion is **not** in the compound being tested.

General comments

The vast majority of candidates successfully attempted all of the questions. The paper was generally well answered, with very few blank spaces.

In answering the planning question (**Question 3**), there is no need for candidates to spend time writing a list of variables or to write a list of apparatus at the start, nor the aims of the experiment. Where there is credit available for the use of suitable apparatus, then that is only awarded if it is stated what the apparatus is used for; credit will not be awarded just for a name in a list of other apparatus.

Comments on specific questions

Question 1

(a) Candidates performed well on this part, with most being able to read burette scales and calculate the volumes added. A large number of responses did not give all burette readings to a consistent number of decimal places, for example 21 rather than 21.0. Some candidates gave readings to a consistent number of significant figures, rather than decimal places and so, for example, recorded the numbers such as 9.20 alongside 21.0. All readings should be to a consistent number of decimal places. A small minority of candidates added the two burette readings to calculate the titre rather than subtracted them. Others recorded some of the readings as 25 or 50 cm^3, suggesting a lack of familiarity with titrations.

(b) The reason for use of a white tile in the titration caused some candidates a problem. The better candidates could state 'it enabled the colour change or the cloudiness due to the precipitate to be seen more clearly'. It was not sufficient to just say that the tile 'allowed the colours to be seen' – they can be seen anyway but the tile makes them clearer. Other common errors were to state the tile protected the bench or lifted the flask up higher.

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(c) (i) Most candidates correctly stated that rinsing with water was to clean the burette and conical flask by removing residues from the previous experiment.

(ii) This proved more demanding than **(c)(i)**, although many candidates stated the need to remove water (as it would dilute solution **B**). Some thought that there may still be some solution **A** in the burette despite having just rinsed it with water.

(iii) Many candidates realised that rinsing the flask with aqueous ammonia would result in a small amount of ammonia remaining in the flask. Hence, the flask would contain the 25 cm^3 measured plus the remains from rinsing which would lead to more solution **B** being required. From the answers seen it was evident that some candidates misread the question and thought the burette was being rinsed with aqueous ammonia.

(d) (i) Better performing candidates correctly stated that solution **B** was the more concentrated and correctly explained that a smaller volume of solution **B** than solution **A** reacted with the same volume of aqueous ammonia. A common error was to state that solution **A** was the more concentrated because a greater volume of solution **A** was required.

(ii) The majority of candidates correctly divided the bigger titre by the smaller to produce an answer. However, the most common errors were to divide the smaller titre by the larger, which give an answer of <1 (and so did not answer the question for how many times more concentrated the solution was) or to just subtract one titre from the other and so calculate the difference in the two titres. It was expected that an answer was given to at least one decimal place, correctly rounded if necessary. Thus, answers stating that the volume was nearly doubled were not precise enough to gain credit.

(e) Almost all candidates stated that the experiment should be repeated, but many of those did not go on to say that the answers obtained from the repeated experiments should be compared. Without a comparison of the titres obtained it is not possible to tell if the results obtained are reliable.

(f) Most candidates correctly calculated the expected titre based on the titre obtained in Experiment 1. A common error was to base the calculation on the final burette reading in Experiment 1 rather than the titre. Most candidates remembered that physical quantities require units, although some omitted the units.

(g) Almost all candidates were able to correctly state that a volumetric pipette was more accurate than a measuring cylinder. A range of different disadvantages were seen; the fact that a volumetric pipette only measures a fixed volume is not a disadvantage in this experiment as the volume of aqueous ammonia was 25 cm^3 in every experiment. It was evident that some candidates were not familiar with volumetric pipettes and so were trying to compare the use of a measuring cylinder to a dropping or Pasteur pipette.

Question 2

(a) Whilst most candidates spotted the change in state from a solid to a liquid, far fewer mentioned the condensation on the sides of the boiling tube.

(b) Very few candidates realised that solid **E** was hydrated or contained water (of crystallisation), largely due to lack of a correct observation in **(a)**.

(c) Most candidates observed a red-brown precipitate that did not dissolve in excess, although there were some incorrect descriptions of the colour. Very few candidates appeared to be unfamiliar with the term ‘precipitate’.

(d) The majority of candidates correctly identified ammonia as the gas, although a number did not say that it turned damp red litmus blue as an observation. A few appeared to get positive tests for other gases, usually carbon dioxide, hydrogen or oxygen.

(e) Two colours were required here, the colour immediately after the solutions were mixed and the colour after standing for three minutes (which was back to the original colour). Most candidates just gave one of these colours.

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(f) Most candidates correctly described the positive result of this test for sulfate ions.

(g) This test for halide ions should have given a negative result but a number appeared to have seen a white precipitate.

(h) Most candidates correctly saw a red-brown precipitate.

(i) Two colour changes were expected, the brown of the aqueous iodine after addition of aqueous potassium iodide and then the blue-black after the addition of starch solution. Although a few did give both colours, most only gave one - usually the final colour.

(j) This was the test for sulfite ions and the vast majority did get a negative result, with the solution going a pink/purple colour.

(k) Most candidates correctly identified that sulfate ions were present. Iron(III) was also often identified correctly, although some candidates omitted the oxidation state of the iron. The third ion proved much more demanding, with many candidates suggesting incorrectly that nitrate ions were present rather than ammonium ions. A number of candidates chose to use only formulae to represent the ions rather than names and, in some cases, wrote an incorrect ionic charge.

Question 3

Some excellent and succinct descriptions of this preparation were seen, with a good proportion of candidates gaining full credit.

This planning task was a qualitative preparation of cobalt(II) sulfate. As it was a qualitative task, there was no need to measure volumes or masses.

Good responses included the following points:

- add an excess of cobalt(II) oxide to dilute sulfuric acid in a suitable container such as a conical flask
- heat and stir the mixture
- filter the mixture to remove excess cobalt(II) oxide
- evaporate the filtrate by heating to the point of crystallisation
- cool the solution and isolate the dry crystals by filtration or drying the crystals with filter paper.

The most common errors were omissions. Many candidates did not specify that the base should be in excess (although the best candidates explained why it should be in excess), some did not mention any container to carry out the reaction in and some specified an unsuitable container such as a measuring cylinder. Some candidates specified that cold acid should be used and that it would need leaving a long time because the reaction was slow rather than using warmed sulfuric acid.

A small but significant minority of candidates missed out entirely the stages in which cobalt(II) sulfate solution was made and instead chose to start with cobalt(II) sulfate solution.

It should be noted that there is no need for candidates to write a list of aims and apparatus at the start of their answers. The aim of the plan is in the question and credit will not be given for listing items of apparatus; where credit is available for the selection of an appropriate item of apparatus then it must be clear in the plan for what the item of apparatus will be used.

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Paper 0620/52
Paper 5 Practical Test

Key messages

- The Confidential Instructions state that the supervisor must do the experiments in **Questions 1** and **2** and record the results on a copy of the Question Paper. These results must then be included with the scripts from the centre when they are returned. Where the practical exam has taken place in more than one practical session or laboratory, it should be clear which set of supervisor's results are for which session or laboratory and also which candidates were in which session or laboratory.
- It is essential that centres make up solutions and provide apparatus in accordance with the details contained in the Confidential Instructions. If there is difficulty in obtaining some substances, then the centre should contact Cambridge Assessment for advice.
- When plotting graphs, points should be plotted as a cross (x) or an encircled dot (⦿) and not obscured by the graph line, which should be drawn using a sharp pencil. Lines of best fit should be smooth curves or ruler-drawn straight lines, they should not wobble from point to point. Candidates will need to decide if the points lie on a straight line or a curve.
- In the qualitative analysis question (**Question 2**), where a question states, 'Test any gas produced' then candidates are expected to test the gas and record the details for the gas test that gave a positive result. Candidates are expected to use the term 'precipitate' when describing the formation of a solid from the reaction between two solutions; if when two solutions are mixed the product becomes cloudy and opaque then a precipitate has been formed.

General comments

The majority of candidates successfully attempted all of the questions and the full range of marks was seen. The majority of candidates were able to complete all three questions in the time available. The paper was generally well answered, with very few blank spaces.

In **Question 1**, most candidates obtained results that showed the expected trend, although some candidates obtained times that were either longer or shorter than those expected. This may have been due to issues with making up the solutions or the size of the reaction vessel used.

In answering the planning question (**Question 3**), there is no need for candidates to write a list of apparatus at the start, the aims of the experiment or a list of safety precautions. Where there is credit available for the use of suitable apparatus, then this will only be awarded if it is stated what the apparatus is used for. Credit will not be awarded just for a name in a list of other apparatus.

Comments on specific questions

Question 1

(a) The vast majority of candidates successfully completed the investigation and recorded results for all five experiments. Almost all candidates obtained results that showed a decreasing time as temperature increased and recorded a temperature for Experiment 1 that was close to the Supervisor's result. A small number of candidates did not follow the instruction to record time in seconds to the nearest whole number. The instructions stated not to heat any solution to a temperature of above 55 °C; candidates who recorded a temperature in excess of this were not awarded full credit for completing Table 1.1.

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(b) The colour change required was the brown, orange or yellow colour of the aqueous iron(III) nitrate suddenly changing on addition of aqueous sodium thiosulfate. It was not uncommon for candidates to record the gradual change that occurred after the aqueous sodium thiosulfate was added and the solution slowly lightened so that the text became visible once more.

(c) The vast majority of candidates were able to select an appropriate scale and plot the five points accurately. When drawing a line of best fit, candidates should remember that a best-fit line should be a single, thin, smooth straight-line or curve and that the line does not need to coincide exactly with any of the points. Where there is scatter evident in the data, examiners expect a roughly even distribution of points either side of the line over its entire length.

(d) Almost all candidates were able to identify Experiment 5 as having the fastest rate of reaction. A small minority just said that it was the experiment with the highest temperature but did not say which experiment that was.

(e) Candidates who produced a *y*-axis that ran from 0 to 60 found this question more difficult. Candidates who showed suitable extension of the axis to beyond the grid in order to answer the question were able to gain full credit. Better performing candidates showed appropriate working on the graph. Ideally, this would be a horizontal line starting at 65 seconds and going to the graph line and then down to the *x*-axis where the reading is taken. A common reason for not obtaining full credit was not showing any working on the graph.

(f) Most candidates realised that cotton wool would act as an insulator, but many of those who stated this, did not then go on to say this would result in the temperature of the reaction mixture remaining more constant. A common error was to state the temperature would be more accurate. This is incorrect as the accuracy of the temperature recorded at the end of the experiment is a function of the thermometer used. Some candidates confused this reaction with mass loss from the reaction of calcium carbonate with an acid and stated the cotton wool would let gases escape.

(g (i) The vast majority of candidates correctly referred to the better accuracy of a burette compared to a measuring cylinder.

(ii) The problem with using a pipette in this investigation is the slow rate at which the liquid runs out of a pipette which would mean the reaction would start some time before all of the aqueous sodium thiosulfate had been added. Better performing candidates explained this problem very clearly. A common incorrect answer was to state that pipettes only measure a fixed volume – that is not an issue in this investigation, as the volume of aqueous sodium thiosulfate is fixed at $5\,cm^3$.

(h) Better performing candidates correctly stated that the reaction would be occurring while the reaction mixture was being heated and so the independent variable would not be controlled.

(i) Many candidates stated that the rate of reaction would be unchanged and gave a correct reason for this in terms of solution concentrations or temperature. However, the question was not asking about the rate of the reaction, the question asked about how the results would change. In the experiment the result being measured, the dependent variable, was the time taken for the text to become visible. As a larger beaker would result in a shallower depth of solution in the beaker, the text would become visible more quickly as it is being obscured by a lesser depth of solution.

Question 2

(a) The flame test colour produced by barium ions can be difficult to see and is often masked by the yellow colour of sodium ions which may be an impurity in the sample used, hence the supervisor's results, where the centre provided them, were used in marking this question. It was evident that some candidates were not familiar with conducting a flame test as they gave answers based on solutions bubbling.

(b) (i) Credit was available for describing and recording the result of a positive gas test the candidate carried out. Credit was also available for an appropriate observation made during the reaction. Most candidates correctly noted that effervescence occurred in the boiling tube. As the reaction being carried out was the test for nitrate ions, candidates should have tested with damp red litmus paper and noted that it became blue.

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(ii) Most candidates correctly stated that the gas produced was ammonia.

(c) Most candidates correctly noted the formation of a white precipitate. A minority reported fizzing or that there was no change, this is only possible if the candidates have used incorrect solutions for the test.

(d) Most candidates gained credit for identifying the cation present. Few gave the correct identification of the cation, as it was often incorrectly stated to be ammonium.

(e) Better performing candidates gave fully correct and detailed observations. Candidates should have noticed that solid **G** became a liquid, (it becomes a solution as it dissolves in its own water of crystallisation), or that the solid then became brown or black and that condensation formed nearer the top of the test-tube. Some candidates carried out gas tests and reported the results despite not having been asked to do so.

(f) Candidates were asked to, 'Test any gas produced', and so credit was available for describing and reporting the result of a positive gas test that they carried out. The expected observations were that there was 'effervescence', the 'solid dissolved to form a green, yellow, orange or brown solution' and that, when tested, 'the gas turned limewater milky'. Some candidates gave incorrect observations.

(g) Most candidates correctly reported the formation of a green precipitate, although some candidates must have used incorrect solutions as impossible results, such as 'no change' were sometimes seen.

(h) Better performing candidates correctly identified solid **G** as iron(II) carbonate. A common error was to suggest that the cation was chromium(III) rather than iron(II), both of which give a green precipitate with a few drops of aqueous sodium hydroxide. However, in this question the aqueous sodium hydroxide was added in excess and so the formation of the green precipitate indicates iron(II) ions.

Question 3

This extended planning question was well answered with many candidates gaining full credit. Candidates made good use of the data provided.

This was a quantitative task and so candidates had to ensure that appropriate measurements were made and included in their plans.

The vast majority of candidates used a method based on mixing with water to remove ethanoic acid and propanol followed by using dilute nitric acid to react with the iron(III) oxide. The first step using water is not required as the information in Table 4.1 states that ethanoic acid and propanol both dissolve in dilute nitric acid.

Good responses included the following steps in the plan:
- Add a known mass of metal polish to dilute nitric acid in a beaker or conical flask and heat the mixture.
- Filter the mixture to isolate the unreacted silicon(IV) oxide.
- Wash and dry the silicon(IV) oxide residue.
- Find the mass of the residue.
- Calculate the percentage by mass by dividing the mass of the residue by the mass of the polish and multiplying the result by 100.

Many excellent and succinct answers were seen. However, a common reason for candidates not obtaining full credit was the omission of details. Some candidates did not specify a suitable container in which to carry out the reaction or used an unsuitable container such as a measuring cylinder. Another common error was omitting the important stage of drying the silicon(IV) oxide after filtration. Some candidates mixed up the terms 'residue' and 'filtrate' and so described process carried out on the wrong part of the mixture.

Candidates would be well advised to plan the investigation before beginning to write their response.

A small minority of candidates used the individual components of the metal polish rather than investigated a sample of the metal polish.

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It should be noted that there is no need for candidates to write a list of aims and apparatus at the start of their answers. The aim of the plan is in the question and credit will not be given for listing items of apparatus; where credit is available for the selection of an appropriate item of apparatus, then it must be clear in the plan for what the item of apparatus will be used. Writing a list of dependent, independent and control variables is also not necessary.

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Paper 0620/53
Paper 5 Practical Test

Key messages

- The Confidential Instructions state that the Supervisor must do the experiments in **Questions 1** and **2** and record the results on a copy of the Question Paper. These results must then be included with the scripts from the centre when they are returned. Where the practical exam has taken place in more than one practical session or laboratory, it should be clear which set of Supervisor's results are for which session or laboratory and also which candidates were in which session or laboratory. Confidential instructions are sent to centres once final entries have been made. When the Confidential Instructions have been received, they should be opened as early as is allowed and the chemicals and apparatus required checked and purchased if necessary.

- When plotting graphs, points should be plotted as a cross (x) or an encircled dot (⊙) and not obscured by the graph line, which should be drawn using a sharp pencil. Lines of best fit should be smooth curves or ruler-drawn straight lines; they should not wobble from point to point. Candidates will need to decide if the points lie on a straight line or a curve.

- In the qualitative analysis question (**Question 2**), where a question states, 'Test any gas produced' then candidates are expected to test the gas and record the details for the gas test that gave a positive result. Candidates are expected to use the term 'precipitate' when describing the formation of a solid from the reaction between two solutions; if when two solutions are mixed the product becomes cloudy and opaque then a precipitate has been formed.

- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit will not be awarded.

- In qualitative analysis, not all the tests described will necessarily give a positive result; a negative test result is useful since it tells us that a certain ion is **not** in the compound being tested.

General comments

The majority of candidates successfully attempted all of the questions and the full range of marks was seen. The majority of candidates were able to complete all three questions in the time available. The paper was generally well answered, with very few blank spaces.

In **Question 1**, most candidates obtained results that showed the expected trend, although some candidates obtained temperatures that were outside of the expected range.

In answering the planning question (**Question 3**), there is no need for candidates to write a list of apparatus at the start, the aims of the experiment, or a list of safety precautions. Where there is credit available for the use of suitable apparatus, this will only be awarded if it is stated what the apparatus is used for. Credit will not be awarded just for a name in a list of other apparatus.

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Comments on specific questions

Question 1

(a) The majority of candidates successfully completed the investigation and recorded results for all six experiments. Almost all candidates obtained results that showed a decreasing temperature as the mass of citric acid increased and recorded a temperature for Experiment 1 that was close to the Supervisor's result.

(b) The majority of candidates were able to select an appropriate scale and plot the six points accurately. When drawing a line of best fit, candidates should remember that a best-fit line should be a single, thin, smooth straight-line or curve and that the line does not need to coincide exactly with any of the points. Where there is scatter evident in the data, examiners will expect a roughly even distribution of points either side of the line over its entire length.

(c) While many candidates correctly stated the reaction was endothermic, a significant proportion of candidates stated it was exothermic. For the explanation, candidates were expected to refer to the temperature decrease during the reaction. However, some candidates gave confused answers based on energy loss to or energy gain from the surroundings.

(d) This was almost always answered correctly, although a small minority of candidates identified Experiment 2 as having the greatest temperature change compared to Experiment 1.

(e) Most candidates gained full credit here. Better performing candidates showed appropriate working on the graph, with a vertical line starting at 3.5 g and going to the graph line and then horizontally across to the *y*-axis where the reading was taken. Many candidates did not show any working on the graph.

(f) Most candidates correctly stated that stirring would mix the solids together. Better performing candidates then went on to say that this would allow the two solids to react with each other. Only a small minority mentioned that stirring would ensure the temperature was the same throughout the reaction mixture.

(g) Many candidates correctly stated that the polystyrene would act as an insulator. Only a minority then went on to state that this would result in less heat energy being gained from the surroundings and so would prevent the temperature increasing.

Question 2

(a) Almost all candidates were able to correctly describe the appearance of solid **H**.

(b) As solid **H** was potassium aluminium sulfate, the expected result from the flame test was a lilac flame. It is important that centres provide a set of Supervisor's results, as the result from a contaminated sample can be taken into account when marking scripts. A large number of candidates gave results, such as 'bubbling', that could not have been obtained from a flame test.

(c) Most candidates stated that the solid became a liquid, (it dissolves in its own water of crystallisation), but many candidates did not then go onto say the colour of the liquid formed. Few candidates reported seeing steam being given off or droplets of condensation forming on the walls of the boiling tube.

(d) Many candidates noted the formation of a white precipitate. This should have been evident on dropwise addition and then should not have redissolved in excess. Some impossible observations, such as effervescence, were seen.

(e) Many candidates noted the formation of a white precipitate. Some candidates did not observe the precipitate then redissolving in excess, which suggests that either excess sodium hydroxide was not added or that the contents of the test-tube were not mixed so that the aqueous sodium hydroxide just sat above the previously formed precipitate. It is important when carrying out qualitative reactions that the contents of boiling and test-tubes are mixed.

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(f) (i) This test was for sulfite ions. There should have been no reaction and so adding acidified aqueous potassium manganate(VII) should have resulted in a pink solution forming. The majority of candidates noted this, although they also stated the solution formed was purple or deep purple. This suggests that far more than a few drops of the test reagent were added.

(ii) Despite the acidified aqueous potassium manganate(VII) not becoming colourless in **(f)(i)**, a significant number of candidates suggested incorrectly that solid **H** was a sulfite.

(g) Most candidates correctly noted the formation of a white precipitate. A minority reported fizzing or that there was no change, this is only possible if the candidates have used incorrect solutions for the test.

(h) Better performing candidates used the mark allocation of [2] to realise that two observations were required. While most candidates noted the formation of a white precipitate, the effervescence that should have occurred was noted by only a minority.

(i) Better performing candidates correctly identified all three ions. The flame test in **(b)** should have indicated that solid **H** contained potassium ions. It should be noted that an orange flame test does not indicate calcium ions, which give an orange-red or brick red colour. Some candidates named three compounds rather than three ions.

Question 3

Some excellent and succinct descriptions of this quantitative task were seen. Some candidates gained full credit.

A common error was to measure how quickly oxalic acid dissolved, rather than how much oxalic acid dissolved.

There were a number of possible routes through this quantitative planning task. All methods should have included:
- use of a known or measured or stated volume of solvent
- use of a known or measured or stated mass of oxalic acid
- use of an appropriate container – such as a beaker
- stirring the mixture of solvent and oxalic acid to aid dissolving
- repeating the method with both ethanol and water as solvents.

It should be noted that for liquids, candidates are required to use the term ‘volume’ rather than ‘amount’ and for solids they should refer to ‘mass’.

The two most common methods were:
- to add a known mass of oxalic acid to a fixed volume of solvent, remove the oxalic acid that had not dissolved and determine the mass of the undissolved oxalic acid

or
- to add small portions of a known mass of oxalic acid to a set volume of solvent and stop adding when no more would dissolve.

There is no need for candidates to write a list of aims, apparatus or the independent, dependent and control variables, at the start of their response. The aim of the plan is in the question and credit will not be given for listing items of apparatus. Where credit is available for the selection of an appropriate item of apparatus then it must be clear in the plan for what the item of apparatus will be used.

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Paper 0620/61
Paper 6 Alternative to Practical

Key messages

- Readings recorded from a given item of apparatus should all be recorded to the same resolution (the same number of decimal places).
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit will not be awarded.
- In qualitative analysis, not all the tests described will necessarily give a positive result; a negative test result is useful since it tells us that a certain ion is **not** in the compound being tested.

General comments

The majority of candidates successfully attempted all of the questions. The paper was generally well answered, with very few blank spaces.

In answering the planning question (**Question 4**), there is no need for candidates to spend time writing a list of variables, to write a list of apparatus at the start or the aims of the experiment. Where there is credit available for the use of suitable apparatus, then credit will only be awarded if it is stated what the apparatus is used for. Credit will not be awarded just for a name in a list of other apparatus.

Comments on specific questions

Question 1

(a) The majority of candidates were able to correctly identify **A** as a conical flask.

(b) Many candidates correctly stated that the use of hot water would either speed up the rate of dissolving or would increase the solubility of the sugar so that more would dissolve. A common incorrect answer was to state that higher temperatures increased the rate of the reaction. While it is true that the rate of a reaction is increased by using a higher temperature, there was no reaction occurring at this stage – the process was dissolution.

(c) The majority of candidates correctly named the required process as filtration. However, significantly fewer drew a correct diagram. Common errors were to either omit the funnel or the filter paper.

(d) The question produced a range of answers. Many candidates correctly stated that the enzymes in yeast would be denatured at high temperatures or that fermentation does not occur at high temperatures. A common answer that did not gain credit was to state that the yeast became denatured at high temperatures. Some candidates incorrectly thought that the reaction would become too fast at high temperatures.

(e) The vast majority of candidates correctly stated that the limewater would become milky or cloudy due to the production of carbon dioxide.

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(f) Most candidates could state the bubbles would stop being formed when fermentation was complete. Common errors were to state that the limewater would stop changing. While this is true, it is not something which can be readily observed – either the limewater will be cloudy and it will remain cloudy or if so much carbon dioxide has been passed through the limewater that it has turned clear again, then it will just remain clear. Answers stating that no more gas or carbon dioxide was produced, whilst correct statements, did not gain credit as they are not observations.

(g) Most candidates correctly identified distillation as the appropriate process to separate ethanol from the fermentation mixture.

Question 2

(a) Candidates performed well on this question. Most candidates were able to read the burette scales and calculate the volumes added. Many gave all burette readings to a consistent number of decimal places. However, some candidates recorded the initial reading in Experiment 2 as 21 rather than 21.0. Some candidates gave readings to a consistent number of significant figures, rather than decimal places and so, for example, recorded the numbers such as 9.20 alongside 21.0. All readings should be to a consistent number of <u>decimal</u> places. A small minority of candidates added the two burette readings to calculate the titre rather than subtracted them.

(b) The reason for use of a white tile in the titration caused some candidates a problem, possibly due to reduced amount of practical work that some centres have been able to carry out over the last few years. The better performing candidates could state it enabled the colour change or the cloudiness due to the precipitate to be seen more clearly. It was not sufficient to just say that the tile allowed the colours to be seen – they can be seen anyway but the tile makes them clearer. Other common errors were to state the tile protected the bench or lifted the flask up higher.

(c) (i) Most candidates correctly stated that the rinsing with water was to clean the burette and conical flask by removing residues from the previous experiment.

(ii) This proved more demanding than **(c)(i)**. Many candidates stated the need to remove water (as it would dilute solution **B**); some thought that there may still be some solution **A** in the burette despite having just rinsed it with water.

(iii) Many candidates realised that rinsing the flask with aqueous ammonia would result in a small amount of ammonia remaining in the flask. Hence, the flask would contain the 25 cm^3 measured plus the remains from rinsing which would lead to more solution **B** being required. From the answers seen, it was evident that some candidates misread the question and thought the burette was being rinsed with aqueous ammonia.

(d) (i) Better performing candidates correctly stated that solution **B** was the more concentrated and correctly explained this by stating that a smaller volume of solution **B** than solution **A** reacted with the same volume of aqueous ammonia. The most common error was to state that solution **A** was the more concentrated because a greater volume of **A** was required.

(ii) The majority of candidates correctly divided the bigger titre by the smaller to produce an answer of $\times 1.5$. However, the most common errors were to divide the smaller titre by the larger which give and answer of <1, and so did not answer the question for how many times more concentrated the solution was, or to just subtract one titre from the other and so calculate the difference in the two titres. Answers stating that the volume was nearly doubled were not precise enough to gain credit.

(e) Almost all candidates stated that the experiment should be repeated, but many of those did not go on to say that the answers obtained from the repeated experiments should be compared. Without a comparison of the titres obtained, it is not possible to tell if the results obtained are reliable.

(f) Most candidates correctly calculated the expected titre based on the titre obtained in Experiment 1. A common error was to base the calculation of the final burette reading in Experiment 1 rather than the titre. Most candidates remembered that physical quantities require units, although some omitted the units and so did not gain credit.

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(g) Almost all candidates were able to correctly state that a volumetric pipette was more accurate than a measuring cylinder. A range of different disadvantages were seen. The fact that a volumetric pipette only measures a fixed volume is not a disadvantage in this experiment as the volume of aqueous ammonia was $25\,cm^3$ in every experiment. It was evident that some candidates may not be familiar with volumetric pipettes and so were trying to compare the use of a measuring cylinder to a dropping or Pasteur pipette.

Question 3

(a) This question proved demanding, with only the better performing candidates realising that the formation of steam and condensation suggested that solid **E** contained water and so was hydrated.

(b) Most candidates correctly identified the gas as ammonia.

(c) **Test 4** in Table 3.1 gave a negative result and so it tells us what was **not** present in solid **E**. As the test described was the test for halide ions, it told us that the ions chloride, bromide and iodide were not present. Some candidates stated that there were no halogens present; this statement was ignored, and credit was not awarded as the test is a test for halide ions and not a halogen.

(d) Most candidates correctly identified that sulfate ions were present. Iron(III) was also often identified correctly, although some candidates omitted the oxidation state of the iron. The third ion proved much more demanding with many candidates suggesting incorrectly that nitrate ions were present rather than ammonium ions. A number of candidates chose to use only formulae to represent the ions rather than names. In some cases, they gave an incorrect ionic charge.

(e) This was well answered, with most candidates correctly stating a white precipitate would form and that the precipitate would dissolve in excess to form a colourless solution.

(f) Almost all candidates correctly described the positive result of this test for sulfite ions.

(g) The answer of 'white precipitate', the positive test result for sulfate ions, was seen as often as the correct answer of 'no visible change'. Both sulfite and carbonate ions will form a white precipitate in this test if the nitric acid is omitted. The use of nitric acid ensures that only sulfate ions will result in the formation of a white precipitate.

Question 4

Some excellent and succinct descriptions of this preparation were seen, with a good proportion of candidates gaining full credit.

This planning task was a qualitative preparation of cobalt(II) sulfate. As it was a qualitative task, there was no need to measure volumes of masses.

Good responses included the following points:
- add an excess of cobalt(II) oxide to dilute sulfuric acid in a suitable container such as a conical flask
- heat and stir the mixture
- filter the mixture to remove excess cobalt(II) oxide
- evaporate the filtrate by heating to the point of crystallisation
- cool the solution and isolate the dry crystals by filtration or drying the crystals with filter paper.

The most common errors were omissions. Many candidates did not specify that the base should be in excess (although the best candidates explained why it should be in excess), some did not mention any container to carry out the reaction in and some specified an unsuitable container such as a measuring cylinder. Some candidates specified that cold acid should be used and that it would need leaving a long time because the reaction was slow rather than using warmed sulfuric acid.

A small but significant minority of candidates missed out entirely the stages in which cobalt(II) sulfate solution was made and instead chose to start with cobalt(II) sulfate solution.

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It should be noted that there is no need for candidates to write a list of aims and apparatus at the start of their answers. The aim of the plan is in the question and credit will not be given for listing items of apparatus; where credit is available for the selection of an appropriate item of apparatus then it must be clear in the plan for what the item of apparatus will be used.

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Paper 0620/62
Paper 6 Alternative to Practical

Key messages

- When plotting graphs, points should be plotted as a cross (x) or an encircled dot (⊙) and not obscured by the graph line, which should be drawn using a sharp pencil. Lines of best fit should be smooth curves or ruler-drawn straight lines; they should not wobble from point to point. Candidates will need to decide if the points lie on a straight line or a curve.
- In the qualitative analysis question (**Question 3**) where a question states, 'Any gas given off is tested', then candidates are expected to record the details for the gas test that gives a positive result. Candidates are expected to use the term 'precipitate' when describing the formation of a solid from the reaction between two solutions; if when two solutions are mixed the product becomes cloudy and opaque, then a precipitate has been formed.
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit will not be awarded.
- In qualitative analysis, not all of the tests described will necessarily give a positive result; a negative test result is useful since it informs that a certain ion is **not** in the compound being tested.
- To state that a gas is given off is **not** an observation. The relevant observation would be effervescence or fizzing or bubbles (of a gas).

General comments

The vast majority of candidates successfully attempted all of the questions and were able to complete all questions in the time available. The paper was generally well answered, with very few blank spaces.

When answering the planning question (**Question 4**), there is no need for candidates to write a list of apparatus at the start, nor the aims of the experiment, nor a list of safety precautions. Where there is credit available for the use of suitable apparatus, then this will only be awarded if it is stated what the apparatus is used for; this will not be awarded just for a name in a list of other apparatus.

Comments on specific questions

Question 1

(a) The vast majority of candidates correctly identified the apparatus as a beaker, although trough and ice bath were also acceptable.

(b) Most could place the 'heat' arrow in the correct place, although a few heated the ice bath.

(c) This proved to be challenging. The expected answer was that steam has been cooled down by the ice bath and condensed to water, which many candidates correctly answered. However, a significant minority incorrectly thought that it was the lead (or lead(II) oxide or methane) that was collected here.

(d) A large proportion of answers correctly suggested that there was increased surface area and therefore a faster reaction.

(e) The expected answer was that methane is a flammable gas. However, a more common answer was that it is a toxic gas, which is incorrect.

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Question 2

(a) The vast majority of candidates successfully completed the table with all five times and all five temperatures. The most common error was to not record all temperatures to one decimal place, such as 27 rather than 27.0 °C. A few also recorded time in minutes and seconds rather than just seconds.

(b) The vast majority of candidates were able to select an appropriate scale and plot the five points accurately. Some candidates selected a scale that made the plotting of results difficult. When drawing a line of best fit candidates should remember that a best-fit line should be a single, thin, smooth straight-line or curve and that the line does not need to coincide exactly with any of the points; where there is scatter evident in the data, a roughly even distribution of points either side of the line over its entire length is expected.

(c) Almost all candidates were able to identify Experiment 5 as having the fastest rate of reaction. A small minority just said that it was the experiment with the highest temperature but did not say which experiment that was.

(d) Most candidates gained full credit here. Ideally, the appropriate working on the graph was shown as a horizontal line starting at 55 seconds and going to the graph line and then down to the *x*-axis where the reading was taken. This working was missing in a number of responses.

(e) Most candidates realised that cotton wool would act as an insulator, but many of those who stated this did not then go on to say this would result in the temperature of the reaction mixture remaining more constant. A common error was to state the temperature would be more accurate, this is incorrect as the accuracy of the temperature recorded at the end of the experiment is a function of the thermometer used. Some candidates confused this reaction with mass loss from the reaction of calcium carbonate with an acid and stated the cotton wool would let gases escape.

(f) (i) The vast majority of candidates correctly referred to the improved accuracy of a burette compared to a measuring cylinder.

(ii) The problem with using a pipette in this investigation is the slow rate at which the liquid runs out of a pipette which would mean the reaction would start some time before all of the aqueous sodium thiosulfate had been added. Stronger responses explained this problem very clearly. A common incorrect answer was to state that ‘pipettes only measure a fixed volume’ – that is not an issue in this investigation as the volume of aqueous sodium thiosulfate is fixed at 5 cm^3.

(g) Better responses correctly stated that the reaction would be occurring while the reaction mixture was being heated.

(h) Many candidates stated that the rate of reaction would be unchanged and gave a correct reason for this in terms of solution concentrations or temperature. However, the question was not asking about the rate of the reaction, the question asked about how the results would change. The result being measured, the dependent variable, was the time taken for the text to become visible. As a larger beaker would result in a shallower depth of solution in the beaker, the text would become visible more quickly as it is being obscured by a lesser depth of solution.

Question 3

(a) It was evident that many candidates were not familiar with conducting a flame test. About half the answers had the idea of using a wire (usually made of nichrome or platinum) or a (wet) splint. Very few went on to use the wire to introduce the sample into a hot/blue/roaring flame.

(b) Most candidates correctly stated that the gas produced was ammonia.

(c) Nearly all candidates gained credit for identifying the cation present, but a significant few went on to identify the anion as ammonium.

(d) About half correctly noted the formation of a white precipitate; others suggested fizzing or that there was no change.

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(e) The expected observations were that there was effervescence (or fizzing or bubbling) and that, when tested, the gas made turned limewater milky. While many correct observations were seen, many candidates stated that a gas was given off, which is not an observation. Others did not give the limewater test or did not give the result of the test.

(f) Most candidates correctly reported the formation of an insoluble green precipitate.

Question 4

This extended planning question was well answered with many candidates getting full credit. Candidates made good use of the data provided.

This was a quantitative task and so candidates had to ensure that appropriate measurements were made and included in their plans.

The vast majority of candidates used a method based on mixing with water to remove ethanoic acid and propanol followed by using dilute nitric acid to react with the iron(III) oxide. The first step using water is not required as the information in Table 4.1 states that ethanoic acid and propanol both dissolve in dilute nitric acid.

Good responses included the following steps in the plan:

- Add a known mass of metal polish to dilute nitric acid in a beaker or conical flask and heat the mixture.
- Filter the mixture to isolate the unreacted silicon(IV) oxide.
- Wash and dry the silicon(IV) oxide residue.
- Find the mass of the residue.
- Calculate the percentage by mass by dividing the mass of the residue by the mass of the polish and multiplying the result by 100.

Many excellent and succinct answers were seen. However, a common reason for candidates not obtaining full credit was the omission of details. Some candidates did not specify a suitable container in which to carry out the reaction or used an unsuitable container such as a measuring cylinder. Another common error was omitting the important stage of drying the silicon(IV) oxide after filtration. Some candidates mixed up the terms ‘residue’ and ‘filtrate’ and so described process carried out on the wrong part of the mixture.

Candidates would be well advised to plan the investigation before beginning to write their response.

A small minority of candidates used the individual components of the metal polish rather than investigated a sample of the metal polish.

It should be noted that there is no need for candidates to write a list of aims and apparatus at the start of their answers. The aim of the plan is in the question and credit will not be given for listing items of apparatus; where credit is available for the selection of an appropriate item of apparatus, then it must be clear in the plan for what the item of apparatus will be used. Writing a list of dependent, independent and control variables is also not necessary.

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CHEMISTRY

Paper 0620/63
Paper 6 Alternative to Practical

Key messages

- When plotting graphs, points should be plotted as a cross (x) or an encircled dot (⊙) and not obscured by the graph line, which should be drawn using a sharp pencil. Lines of best fit should be smooth curves or ruler-drawn straight lines; they should not wobble from point to point. Candidates will need to decide if the points lie on a straight line or a curve.
- Readings recorded from a given item of apparatus should all be recorded to the same resolution (the same number of decimal places).
- In the qualitative analysis question (**Question 3**), where a question states 'any gas given off is tested' then candidates are expected to record the details for the gas test that gives a positive result. Candidates are expected to use the term 'precipitate' when describing the formation of a solid from the reaction between two solutions; if when two solutions are mixed the product becomes cloudy and opaque then a precipitate has been formed. To state that a gas is 'given off' is not an observation. The relevant observation would be 'effervescence' or 'fizzing' or 'bubbles (of a gas)'.
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit will not be awarded.
- In qualitative analysis, not all the tests described will necessarily give a positive result; a negative test result is useful since it tells us that a certain ion is **not** in the compound being tested.

General comments

The majority of candidates successfully attempted all of the questions and the full range of marks was seen. The majority of candidates were able to complete all questions in the time available. The paper was generally well answered, with very few blank spaces.

In answering the planning question (**Question 4**), there is no need for candidates to write a list of apparatus at the start, the aims of the experiment, or a list of safety precautions. Where there is credit available for the use of suitable apparatus, this will only be awarded if it is stated what the apparatus is used for. Credit will not be awarded just for a name in a list of other apparatus.

Comments on specific questions

Question 1

(a) (i) The majority of candidates were able to state that the apparatus shown was used for distillation.

(ii) Most candidates were able to correctly identify **B** as a beaker, although fewer were successful at identifying **A** as a condenser.

(iii) Most candidates indicated correctly that heat should be applied under the liquid in the flask. A small number of candidates drew arrows, which suggested heating the beaker or the condenser.

(b) (i) It was not uncommon for candidates to not read the question carefully and give the answer as 'filtration' rather than 'residue'.

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(ii) Many candidates suggested filtration as an appropriate method, despite that being the method that has just been used. Others incorrectly suggested heating: although this would remove the water, it would not remove the sodium chloride. Only the strongest responses suggested washing the calcium carbonate to remove the aqueous sodium chloride.

(iii) Many candidates correctly suggested the use of evaporation, crystallisation or distillation – all of which would have resulted in obtaining solid sodium chloride from aqueous sodium chloride.

Question 2

(a) Almost all candidates gained credit for recording the masses of sodium carbonate and citric acid. A small number of candidates did not record the thermometer readings to half a scale division and so incorrectly recorded the reading for Experiment 2 as '11' or '12' rather than '11.5' or omitted the negative sign from the two final temperature readings. Most candidates recorded all the masses to one decimal place did this for the masses; they often did not do this for the temperatures.

(b) The vast majority of candidates were able to select an appropriate scale and plot the six points accurately. However, a number of candidates did not gain credit for the scale on the *y*-axis as they either did not continue the scale below zero or produced a non-linear scale below zero with the bottom of the grid being –2 °C rather than –10 °C. When drawing a line of best fit, candidates should remember that a best-fit line should be a single, thin, smooth straight-line or curve and that the line does not need to coincide exactly with any of the points. Where there is scatter evident in the data, examiners will expect a roughly even distribution of points either side of the line over its entire length.

(c) While many candidates correctly stated the reaction was endothermic, a significant proportion of candidates stated it was exothermic. For the explanation, candidates were expected to refer to the temperature decrease during the reaction, however, some candidates gave confused answers based on energy loss to or energy gain from the surroundings.

(d) This was almost always answered correctly, although a small minority of candidates identified Experiment 2 as having the greatest temperature change compared to Experiment 1.

(e) Most candidates gained full credit here. Better performing candidates showed appropriate working on the graph, with a vertical line starting at 3.5 g and going to the graph line and then horizontally across to the *y*-axis where the reading was taken. Many candidates did not show any working on the graph.

(f) Most candidates correctly stated that stirring would mix the solids together. Better performing candidates then went on to say that this would allow the two solids to react with each other. Only a small minority mentioned that stirring would ensure the temperature was the same throughout the reaction mixture.

(g) Many candidates correctly stated that the polystyrene would act as an insulator. Only a minority then went on to state that this would result in less heat energy being gained from the surroundings and so would prevent the temperature increasing.

Question 3

(a) This question proved to be demanding, with only the better performing candidates realising that the formation of condensation and the cobalt(II) chloride paper turning pink meant that water had been given off and so solid **G** must have been hydrated.

(b) **Test 4** was the test for sulfite ions and had a negative result. Only a minority of candidates correctly stated that this showed that solid **G** was **not** a sulfate. Negative test results are useful because they tell us what something is not.

(c) Stronger responses correctly stated that **test 3** showed that the cation in solid **G** was either aluminium or zinc.

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(d) Many candidates correctly used the result of **test 1** to deduce that solid **G** contained potassium ions. However, a significant number stated that it also contained sulfite ions, rather than the correct answer of sulfate ions, which could be deduced from **test 5**.

(e) In this reaction, dilute hydrochloric acid was added to copper(II) carbonate. As this question stated, ‘any gas given off was tested’, candidates were expected to give the appropriate gas test and its result. During the reaction, effervescence should have been seen and a blue or green solution formed; either of these two observations would have gained credit. The expected gas test was to bubble the gas into limewater which should have resulted in the limewater becoming milky in appearance.

(f) The solution formed in **(e)** contained copper(II) ions, hence the addition of copper hydroxide dropwise and then in excess should have resulted in a blue precipitate which did not then redissolve in excess. Some candidates gave two colours, such as blue-green, which was not credited since the precipitate formed is blue.

(g) Most candidates correctly stated that a white precipitate would be formed.

Question 4

Some excellent and succinct descriptions of this quantitative task were seen. Some candidates gained full credit.

A common error was to measure how quickly oxalic acid dissolved, rather than how much oxalic acid dissolved.

There were a number of possible routes through this quantitative planning task. All methods should have included:

- use of a known or measured or stated volume of solvent
- use of a known or measured or stated mass of oxalic acid
- use of an appropriate container – such as a beaker
- stirring the mixture of solvent and oxalic acid to aid dissolving
- repeating the method with both ethanol and water as solvents.

It should be noted that for liquids, candidates are required to use the term ‘volume’ rather than ‘amount’ and for solids they should refer to ‘mass’.

The two most common methods were:

- to add a known mass of oxalic acid to a fixed volume of solvent, remove the oxalic acid that had not dissolved and determine the mass of the undissolved oxalic acid

or

- to add small portions of a known mass of oxalic acid to a set volume of solvent and stop adding when no more would dissolve.

There is no need for candidates to write a list of aims, apparatus or the independent, dependent and control variables, at the start of their response. The aim of the plan is in the question and credit will not be given for listing items of apparatus. Where credit is available for the selection of an appropriate item of apparatus then it must be clear in the plan for what the item of apparatus will be used.

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