CHEMISTRY

Paper 0620/11
Multiple Choice (Core)

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

General comments

Candidates found this to be an accessible question paper overall with many questions showing good discrimination between candidates. Overall, candidates found **Questions 2**, **3**, **16**, **25**, **26**, **32** and **38** to have the least challenge.

Questions 7, **9**, **10**, **11**, **18**, **19**, **27**, **29**, **33** and **40** were most demanding.

The difference between compounds, mixtures and elements was not well recalled.

Many candidates found questions involving numbers or a calculations demanding.

Topics which are relatively new to the syllabus, such as solubility rules or ion testing, particularly using flame tests, were not well known.

Comments on specific questions

Question 7

Few candidates answered this demanding question correctly. The most common answer was option **B** which suggests that many candidates find writing chemical formulae difficult. This question had an additional complication of using the letter X to represent the Group II element. Candidates are advised to check their answer using any Group II element with which they are more familiar, e.g., Mg or Ca.

Question 9

Candidates often find calculations difficult. Most candidates chose option **B** which suggests that many understood the stoichiometric ratio but not the ratio of relative masses. It is recommended that candidates practice finding ratios of relative masses.

Question 10

Although many of the better performing candidates overall answered this correctly, others appeared to have been guessing. Option **D** was the most commonly chosen option by the better performing candidates where the correct electrolyte was chosen but the electrodes were reversed.

Question 11

Electrolysis is often a strong discriminating topic between candidates. Candidates who performed less well overall were more likely to choose any of the options rather than the correct answer. Option **D** was the most common answer, showing partial recall of electrolysis.

Question 18

Fewer than a third of candidates answered this correctly with many choosing option **C**. The colours of common indicators appear to be becoming less well known and centres are encouraged to complete practical work to reinforce their use.

Question 19

Few candidates appear to have learned the solubility rules described in the syllabus. The correct answer was not chosen by many candidates with all the options being more popular.

Question 24

Although the correct answer was the most commonly chosen response, option **C** was chosen by a third of the candidates. They recalled the correct colour but not the correct physical state of bromine at room temperature and pressure.

Question 27

Fewer than one candidate in six answered this question correctly. Over three quarters of the candidates incorrectly thought that silver would react with either dilute hydrochloric only or both steam and dilute hydrochloric acid.

Question 29

Although candidates who performed well overall were slightly more likely to recall the meaning of the term alloy, it was not well known overall. Many candidates confused the terms ‘compound’ and ‘mixture’ and chose option **A**. A few candidates chose option **D**, a pure metallic element.

Question 31

Although this was generally well answered overall, candidates who performed less well overall chose option **D**.

Question 33

The adverse effects of air pollutants were not well recalled. Both option **A** and option **C** were commonly chosen, although few candidates chose option **D.**

Question 40

Flame tests and the test for the nitrate ion test were not well recalled. Option **A** was commonly chosen, although all the options were popular.

CHEMISTRY

Paper 0620/12
Multiple Choice (Core)

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

General comments

The question paper gave a good range of marks with each question showing discrimination between candidates. Overall, fewer candidates came close to the maximum mark.

Candidates found **Questions 1**, **2**, **8** and **30** to have the least challenge.

Questions 10, **32**, **36** and **38** were most demanding.

Questions requiring candidates to recall or to use chemical equations were not well answered. It is recommended that candidates complete further practice writing both formulae and chemical equations involving acids, bases, salts and organic compounds.

Comments on specific questions

Question 4

Each circle represents an atom in the diagram. Each differently shaded circle represents a different element. Joined circles represent bonded atoms. Candidates who performed less well were most likely to choose option **B**, for which the two boxes represent a mixture of elements (P) and a single compound (Q).

Question 7

Most candidates recalled that covalent bonds form when electrons are shared. As a result, few candidates chose option **C** or option **D**. Candidates who performed less well tended to confuse the properties of covalent compounds and, having described the electrons in the bond, assumed that the compound had high conductivity. As a result, they chose option **A**.

For questions like this, it is advised that candidates consider a very familiar compound such as water or carbon dioxide to help in deciding whether the properties listed in the question are correct.

Question 9

Only a small majority of candidates answered this question correctly, and candidates who performed less well overall appeared to have been guessing. The formula of all common acids and alkalis and their reaction products should be practised regularly.

Question 10

This question indirectly assesses the candidates' ability to write chemical formulae. Few candidates answered this question correctly with option **C** being the most commonly chosen option across all ability levels. Option **C** is the relative formula mass for the incorrect formula MgBr.

Question 11

This question tested candidates' understanding of the properties of ionic compounds and metallic elements. Most candidates recalled that solid copper was a conductor, but most confused the conductivity of aqueous and solid salts. Option **C** was the most commonly chosen option.

Question 12

Candidates should recognise that in the hydrogen–oxygen fuel cell, the fuel is hydrogen. The majority of candidates chose option **B** for which one of the reactions would produce oxygen not hydrogen. Most candidates correctly recalled that photosynthesis does not produce hydrogen.

Question 14

Most candidates confused the terms endothermic and exothermic and chose option **C**.

Question 20

The majority of the candidates correctly identified that compound M could not be a carbonate. Most candidates deduced that the compound must be a hydroxide, but few could determine the correct formula of calcium hydroxide and suggested option **A**.

Question 29

Most candidates did not recall that Group VII elements are diatomic. Option **D**, transition elements, was the most commonly chosen option for candidates who performed less well and a third of the candidates overall.

Question 31

The displacement reactions of the halogens was not well known by candidates who performed less well. These candidates were more likely to give any of the options rather than the correct answer and many appeared to have guessed.

Question 32

The most popular option was option **D**. Although an excess of phosphates initially promotes the growth of algae, the algae then uses up the available oxygen and dies. The deoxygenated water produced is harmful to aquatic life. Candidates are not expected to recall any mechanism for this but should recall that (excess) phosphates cause deoxygenation and that some metal compounds and dissolved oxygen are beneficial to aquatic life.

Question 36

A large majority of candidates thought that ethanoic acid would decolourise aqueous bromine. Candidates should be reminded that aqueous bromine rapidly reacts with compounds containing the C=C bond and not the C=O bond. Both option **A** and option **B** were common incorrect answers.

Question 38

Most candidates recalled the use of a burette or a volumetric pipette to measure volumes to a high precision. Candidates should be reminded that volumetric pipettes are only used to measure fixed values. The fixed values include 10 cm^3, 20 cm^3, 25 cm^3, or 50 cm^3 rather than arbitrary values such as 21.50 cm^3. For values such as this, a burette would be used.

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Paper 0620/13
Multiple Choice (Core)

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

General comments

This question paper gave a broad distribution of marks although the average mark was slightly low.

Candidates found **Questions 3**, **23**, **24** and **29** to have the least challenge.

Questions 9, **20**, **25**, **33**, **34** and **35** were most demanding.

For some questions, candidates could have helped themselves by using the Periodic Table to identify information about specific elements such as their chemical name, structure or their symbol.

Candidates should take more time to learn the chemical terms which have similar names such as endothermic and exothermic and saturated and unsaturated. It may be easiest to memorise just one of the pair and to recognise that that other term must be the logical opposite.

Comments on specific questions

Question 5

This question was well answered overall but gave good discrimination between candidates. Almost half of the candidates who performed less well overall chose option **B**. Candidates should be reminded that they are provided with a Periodic Table which would help them answer questions like this.

Question 6

The bonding of simple covalent molecules from the syllabus was only known by a third of the candidates. All the options were popular for this question, and some candidates appeared to be guessing.

Question 9

Fewer than one in seven of the candidates could identify the products of incomplete combustion. This question only showed slight discrimination between candidates because the better performing candidates overall also found it challenging. Candidates should note that when burned in limited supplies of oxygen, hydrocarbons will always produce water along with either carbon monoxide or carbon or both. Smaller amounts of carbon dioxide may also be present. The equation representing the overall reaction must also be balanced.

Question 14

Option **A** was chosen by almost half of all the candidates, showing a confusion of the terms endothermic and exothermic.

Question 15

Option **C** was chosen by the majority of candidates. Some candidates struggled to distinguish between physical and chemical changes. In this question, almost two thirds of the candidates did not recognise that cooking would cause an irreversible change.

Question 20

Candidates do not seem to be familiar with the indicators used. It is recommended that candidates incorporate practical work as part of their preparation such that the common colours of litmus, thymolphthalein and universal indicator are well known.

Question 25

Many candidates confused the total number of electrons or the number of electron shells with the number of outer electrons. Option **D** was a commonly chosen answer. Some candidates recalled that potassium is a very reactive element but did not apply the trend in reactivity to recognise that rubidium is even more reactive. As a result, option **C** was also chosen more frequently than the correct answer.

Question 26

In the diagrams, each circle represents an atom, with different shading representing different elements. Joined circles represent bonded atoms. Candidates who performed less well overall, were most likely to choose option **B**, which represents a pure sample of a molecule.

Question 27

Most candidates recognised that the alloy, brass, conducts electricity. Few candidates chose option **A**. Candidates should take note that brass is harder and stronger than the individual elements and that the major components of brass are copper and zinc.

Question 33

This question was not well answered. All of the options were chosen in preference to the correct answer with option **C** being the most commonly chosen. Refinery gas which contains methane, CH_4, is the hydrocarbon molecule containing five atoms.

Question 34

Candidates who performed less well overall were more likely to choose any of the options. Candidates are advised to use their Periodic table to help them to remember the names of the elements present in NPK fertilisers. The most commonly chosen option was **A**.

Question 35

Most candidates chose option **A** which was the lowest numerical value for the M_r of an organic compound. Candidates are reminded that carbon makes four bonds, oxygen two and hydrogen one bond. A sketch of the possible structures would then aid in identifying the correct answer.

Question 36

This question discriminated well between candidates. Almost half of the candidates who performed less well overall chose option **C**, confusing the terms saturated and unsaturated.

Question 40

Few candidates chose options **B** or **C**, which suggests that most candidates correctly recognised that the volumetric pipette and the burette are the most precise items of glassware used in a titration. Most candidates chose the wrong apparatus for adding the variable amount of solution to the flask. The volumetric pipette, option **D**, is suitable for single fixed values only.

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Paper 0620/21
Multiple Choice (Extended)

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

General comments

Overall, the paper gave a broad range of marks with a small number of candidates close to achieving full marks.

Candidates found **Questions 3**, **9**, **24**, **28** and **29** to have the least challenge.

Questions 6, **10**, **32**, **34**, **35** and **39** were most demanding.

Questions on electrolysis and questions requiring a calculation discriminated well between candidates. The properties of petroleum fractions and the reactions of different homologous series were not well recalled. Organic chemistry was a particular challenge for many candidates.

Comments on specific questions

Question 4

Fewer than half of the candidates recognised that the structure represented an ionic substance containing anions and cations with a single charge. Option **C** was chosen by many candidates which would have an incorrect cation. Over a third of candidates who performed least well overall chose option **D**, carbon monoxide.

Question 5

The structure and bonding of named substances in the syllabus should be well known. It may help candidates in questions like this to make a small, sketched diagram on the question paper of each molecule.

Although most of the candidates who performed well overall answered this question correctly; others were more likely to choose any of the options.

Question 6

Two thirds of the candidates correctly recognised that simple molecules have low boiling points. Only half of these candidates recalled that it is the weak forces between the S_8 molecules rather the bonds/forces between S atoms within the molecule that explain this property. Option **C** was, therefore, the most commonly chosen incorrect answer.

Question 10

Calculations are often found to be challenging questions. Almost two thirds of the candidates chose option **A**, where the candidates ignored the chemicals described and calculated $(85 \div 225) \times 100$. Candidates should recognise that when reacting quantities are given, a more involved calculation is often expected.

Question 12

This question discriminated well between candidates. Very few of the candidates who performed least well overall chose the correct answer. Many candidates confused the anode and the cathode in the electrolysis and chose option **B**.

Question 15

This question discriminated well between candidates. Although, most candidates recognised that a high temperature is used to increase the reaction rate, many incorrectly assumed that the catalyst would increase the reaction yield and chose option **B**.

Question 16

This question was intended as a simple recall question. Only a third of candidates recalled that sulfur, S, is the raw material that is converted first to SO_2 then SO_3 and ultimately to H_2SO_4. Many candidates assumed that it is the sulfur dioxide that is the raw (or starting) material and chose option **C**.

Question 25

This was a strongly discriminating question with nearly all of the candidates who performed well overall answering it correctly, whereas half of the candidates who performed less well chose option **D**. Candidates should inspect the diagram carefully. The position of molten aluminium and the labelled $\oplus$ and $\ominus$ symbols could give help in determining the type of reaction that occurs at each electrode.

Question 26

This question was also intended as a simple recall of gases found in the atmosphere. Option **B** was commonly chosen by candidates who performed less well overall. These candidates did not recognise that carbon dioxide is a compound rather than an element.

Question 32

Most candidates recognised that diesel oil has a higher boiling point than at least one of the other fractions, but both option **B** and option **C** were common incorrect answers.

Question 33

The most commonly chosen option was the correct answer. Option **B** was the most common incorrect answer. The equation shown may represent a kind of substitution reaction but it is not the reaction described in the question. The by-product of the reaction with chlorine in ultraviolet light must be HCl and not H_2.

Question 34

The distribution of options suggests that a significant number of candidates may have been guessing. Candidates should note that the test for unsaturation using aqueous bromine is rapid and not catalysed. This single piece of information would allow all candidates to answer this question correctly.

Question 35

The formation of ethanoic acid was not well recalled. Most candidates chose option **B** or option **C**, which are reactions used to form ethanol not ethanoic acid.

Question 38

Candidates frequently find the identification of polymers challenging and this question was no different. Option **A**, an amino acid, is the name of the monomer of Q, rather than the type of polymer shown by Q. Option **A** was the most commonly chosen incorrect answer.

Question 39

Few candidates chose option **B** or option **D**, showing that most candidates correctly recalled that impurities tend to raise the boiling point of a substance. The most common answer was option **A** where candidates did not recall that impurities tend to lower the melting point.

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Paper 0620/22
Multiple Choice (Extended)

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

General comments

Candidates found this to be an accessible paper, and a broad spread of marks were obtained. A small number of candidates achieved full marks. Nearly all questions showed good discrimination between candidates, although some candidates found the extended paper challenging.

Candidates found **Questions 5**, **9**, **22**, **23** and **27** to have the least challenge.

Questions 7, **10** and **25** were most demanding.

The link between forces between particles, bonding and physical properties was not well known.

Comments on specific questions

Question 2

Most candidates correctly identified that the collisions between particles would occur less often at decreased pressure, but many confused the effect of pressure on the particle speed and chose option **A**.

Question 7

The properties of ionic and simple covalent compounds were not well recalled. Many candidates confused the forces which are overcome during boiling and chose option **B** or they confused the meaning of the term molecule and chose option **C**. Candidates should be reminded that the word ‘molecule’ is used to describe simple covalent substances and not ionic compounds.

Question 10

This was a particularly demanding question. The most common error was to assume that the ratio of gaseous product to solid ammonium carbonate was 1 : 1 rather than 1 : 3, as shown by the equation. As a result, option **D** was the most commonly chosen option.

Question 15

Most candidates correctly recognised that a lower temperature would not cause particles to collide more frequently. They also recognised that lower pressures do not increase the reaction rate, so option **C** and option **D** were not chosen by many candidates. There was strong discrimination between candidates for the remaining options, with candidates who performed less well overall much more likely to choose option **B**.

Question 16

This question showed strong discrimination between the candidates. Most of the candidates who performed less well overall thought that the addition of a catalyst would increase the equilibrium yield and chose options **A** or **B**.

Question 17

Candidates who performed less well overall were more likely to confuse oxidation and reduction and choose option **C**. Candidates should be reminded that reduction will cause a decrease (i.e. a reduction) in the oxidation number. This would help eliminate two of the options in this question.

Question 19

Most candidates correctly recognised that weak acids are not fully dissociated. Candidates who performed less well overall were more likely to link the strength of the acid to the concentration and choose option **C**.

Question 24

This question discriminated well between candidates. The apparent unreactivity of aluminium and the reactivity series was not well known by candidates who performed less well overall; these candidates tended to choose option **C**.

Question 25

Confusion between reduction, oxidation and the movement of electrons was commonly seen in the responses of candidates how performed less well overall. Option **A** was the most common incorrect answer.

Question 26

The role of cryolite in the extraction of aluminium from its ore was not well recalled. The most common incorrect answers were options **B** and **D**.

Question 29

Most candidates correctly recognised that the product of the addition of bromine to but-2-ene could not be option **B** or option **D**. Candidates who performed less well overall were more likely to choose option **A** than the correct answer.

Question 31

The meaning of the term ‘saturated’ was not well recalled by candidates who performed less well overall. These candidates appeared to be guessing with all the options chosen equally.

Question 32

Many candidates assumed that members of the same homologous series have the same number of carbon atoms and chose option **A**.

Question 33

Most candidates knew that methane was either a gas at room temperature or insoluble in water. A third of candidates confused the test for unsaturation or thought that methane was unsaturated and chose option **B**.

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Paper 0620/23
Multiple Choice (Extended)

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

General comments

Candidates found this to be an accessible paper overall with a significant number of candidates achieving most or all available marks.

Candidates found **Questions 1**, **2**, **16**, **28**, **29** and **33** to have the least challenge and no questions posed a significant challenge to the majority of candidates.

Many questions showed good discrimination between candidates. This was particularly clear in questions involving electrolysis, equilibrium or redox.

Comments on specific questions

Question 4

Most candidates recalled that ionic compounds have high melting points and good electrical conductivity when molten. Candidates who performed less well overall were more likely to think that ionic compounds were also electrical conductors when solid and chose option **C**.

Question 7

This question required candidates to determine the formula of an unfamiliar compound using the charges of the component ions to form a neutral compound. Some candidates appeared to misunderstand the significance of the (III) in the name ammonium iron(III) citrate. Some candidates may have misremembered the charge on an ammonium ion. Option **A** was chosen by the majority of candidates.

Question 8

It is expected that candidates should know the physical state of elements and simple compounds from the syllabus. A significant number of candidates thought that silicon(IV) oxide was liquid or that carbon was gaseous at room temperature and pressure. Option **B** was the most common incorrect answer.

Question 10

This question appears, at first glance, to be demanding. The only information given to candidates is the volume and concentration of NaOH(aq) and the volume of HC*l*(aq). As a result, the only step possible as the first step is the determination of the moles of NaOH which was step 4. Most candidates recognised that the final step should be to complete the aim of the question, which was to find the concentration of HC*l* in g/dm^3. This was step 3. Option **B** was the most commonly chosen incorrect answer.

Question 17

Most candidates recognised that removing the catalyst would not change the position of equilibrium. Candidates who performed less well confused the effect of temperature on the exothermic reaction and gave option **B**.

Question 18

Most candidates recognised that the main components of brass are copper and zinc. Candidates who performed less well tended not to use the additional information showing the amphoteric nature of the oxide and chose option **B**.

Question 19

The most common incorrect answer was option **A** where candidates confused the terms oxidation and oxidising agent.

Question 21

Few candidates confused the degree of dissociation and the strength of the acid. The most common incorrect answer was to think that hydrochloric acid only partially dissociates and so is a weak acid. This was option **D**.

Question 24

Over a third of candidates thought that the equation given showed that chromium acted as a catalyst and chose option **A**. Candidates are reminded that catalysts are unchanged at the end of a reaction and that the chromium species was clearly changed during this reaction from $Cr_2O_7^{2-}$ to Cr^{3+}.

Question 34

The bacterial oxidation of ethanol to form ethanoic acid was not well recalled by the candidates. Most candidates recognised that heating ethanol with acidified aqueous potassium manganate(VII) is a suitable method and that distillation is not. The most common incorrect answer was option **B**.

Question 35

This question required candidates to read each statement very carefully. Option **C** was the most common incorrect answer where candidates did not appreciate that it is ethene rather than propene that is used to make poly(ethene). Similarly, many candidates chose option **B**, which describes the use of an alkaline catalyst rather than an acidic catalyst.

Question 37

Most candidates recognised the correct linkage found in a protein and so few chose options **B** or **C**. Candidates should be reminded that the central structure of each animo acid monomer, represented by a shaded rectangle, is connected to both an amine group and a carboxyl group. The most common incorrect answer was option **A**.

CHEMISTRY

Paper 0620/31
Theory (Core)

Key messages

- Candidates should read each question carefully, so they are sure to answer the question asked.
- Candidates should be able to identify all the elements, ions and compounds named in the syllabus.
- The purity of substances and the effect of impurities on physical values was not well known. Candidates should be reminded that impurities typically lower the melting point and raise the boiling point of substances such as water. The impurities also change the points from a single sharp value to a range of values.
- Candidates should take care when answering comparative questions by either giving a statement about each substance or by using comparative adjectives such as higher, faster or larger.
- Qualitative tests were poorly recalled and further practice and practical work would be beneficial.

General comments

Overall, the paper produced a wide range of marks which allowed for discrimination between candidates.

Chemical tests such as those in **Questions 1(a)(i)**, **1(a)(iv)** and **5(c)(ii)**, were not well known. It is recommended that candidates spend more time completing questions of this type in written and practical chemistry.

Most candidates could interpret information from a table and could balance symbol equations.

Few candidates could recall the water pollutants from the syllabus in **Question 3(a)** or complete the stages of water treatment for the domestic supply in **Questions 3(c)(i)** and **3(c)(ii)**.

Candidates should take time to understand key chemical terms and definitions from the syllabus, such as those in **Questions 1(b)**, **2(a)(i)**, **2(c)(i)**, **4(a)(i)** and **4(a)(ii)**. Many descriptions were close to being correct but were often too imprecise to be given credit.

The typical properties of metals in **Question 6(a)** were well known and most candidates could determine a reactivity series from reaction observations in **Question 6(e)**.

The topic of 'acids and bases' would benefit from further revision. Few candidates could identify a suitable acid or alkali used to form potassium chloride in **Question 7(a)(i)**, or how the solid salt could be extracted from its aqueous solution in **Question 7(a)(iv)**.

Sometimes, candidates did not answer the question asked. For example, in **Question 8(b)(i)** many candidates renamed the electrodes rather than naming the electrolysis products. When asked for a comparison, candidates should take care to give a comparative answer such as faster, slower, shorter or longer. Stating that the reaction would 'finish in a short time' does not indicate whether that time is longer or shorter than the original reaction in **Questions 8(a)(ii)** and **8(a)(iii)**.

Comments on specific questions

Question 1

Questions on qualitative analysis such as **(a)(i)** and **(a)(iv)** were found to be challenging. Questions **(a)(ii)** and **(a)(v)** highlighted the confusion of many candidates between shells, periods, groups and the formation of ions.

(a) (i) Some candidates recalled the flame test colour for potassium, although many candidates did recall that a flame test is used to identify a metallic cation.

(ii) A small majority of candidates recognised fluorine as the only atom shown which has only two occupied electron shells. Common errors were to suggest calcium, Ca, as a Group II element, or to choose one of the elements from Period 3.

(iii) This was well answered, with most candidates able to identify the inert gas Argon, Ar.

(iv) This question was found to be challenging. Some candidates gave the symbol for a gaseous element which suggests that they did not recognise this part of the syllabus.

(v) A small majority of candidates answered this correctly. Common incorrect answers included the Group II element calcium, Ca, or the Period 2 element fluorine, F.

(vi) Some candidates recalled that nickel, Ni, is one of the components of stainless steel. Aluminium, A*l*, was a common incorrect answer.

(b) Many candidates were not clear what to write to answer this question. Many described properties of an alloy such as comparative hardness. Some answers were close such as 'contains two or more elements' but this could also apply to the description of a compound.

Question 2

The candidates who performed less well on this question were often unable to describe or give essential chemical terms such as diatomic in **(a)(i)** or anion in **(c)(i)**.

(a) (i) This question was well answered except for the candidates who performed less well, who often described the formation of ionic bonds or stated the number of bonds present.

(ii) A large minority answered this correctly. Many candidates suggested a percentage of nitrogen in clean dry air that was less than 50%.

(b) This question was well answered with many candidates identifying the bonding pairs. A small number omitted the non-bonding pair on the nitrogen or added two or more pairs. Some candidates incorrectly added an extra six non-bonding electrons to each hydrogen atom.

(c) (i) Only the better performing candidates answered this reliably well. The most common answer was 'electrons'. A significant number confused the term with electrodes and suggested anode or cathode.

(ii) Few of the candidates who performed less well could suggest a physical property of an ionic compound and some candidates gave no response. Some candidates gave incomplete answers such as a good electrical conductor, which is ambiguous without reference to the physical state, e.g. aqueous or molten.

(d) (i) Most candidates gave a suitable use for graphite, most commonly as the core of a pencil. A small number of candidates repeated the use in the question which did not gain credit.

(ii) Most candidates recalled the structure and bonding in graphite.

Question 3

Questions requiring candidates to extract information from a table, **(b)(i)**, or to manipulate data, **(b)(iii)**, were well answered. The stages of water purification and the test for water purity was not well known and many candidates offered no response to **(c)(i)**, **(c)(ii)** and **(d)**.

(a) Many candidates struggled to recall the common pollutants listed in the syllabus.

(b) (i) Most candidates answered this question correctly.

(ii) The better performing candidates had no difficulty with this question, although for other candidates this was found to be challenging. The most common answers were nitrogen oxide, nitrogen trioxide or nobelium. Candidates should be able to identify all the ions and compounds named in the syllabus.

(iii) Most candidates answered this question correctly.

(c) (i) Few candidates recalled the chlorination of water as a final step in the production of water for the domestic supply. Some candidates thought that the process was complete and stated 'drinking water' as the final stage. Some candidates gave no response to this question.

(ii) Only a handful of candidates recalled the reason why carbon is used in water treatment. Many confused it with chlorination and suggested 'to kill bacteria' or gave an imprecise answer such as 'to purify the water'. Some candidates did not attempt this question.

(d) Few candidates appeared to understand what this question required them to do. Many described processes that would produce pure water such as distillation. Others described boiling water to dryness and then examining the container for a residue. Some described melting without reference to purity.

Both an experimental method which either described the cooling of water to its freezing point or warming a sample of ice to the melting point and comparison of this value with the known value for pure water (0 °C) were needed. The time taken for water to freeze was not considered creditworthy.

(e) Most candidates answered this question correctly.

Question 4

Questions on organic chemistry are often found to be demanding. Although most candidates answered **(a)(iii)** correctly, most of the other question parts were found to be challenging by many candidates.

(a) (i) A small majority of candidates answered this correctly. Some candidates incorrectly described the number of bonded hydrogen atoms rather than the type of carbon-carbon bonding. A small number confused organic saturation/unsaturation with solubility.

(ii) Many candidates gave near-miss answers such as 'the compounds contain carbon and hydrogen'. The omission of the word 'only' gave an answer that could include alcohols which are not hydrocarbons. Some candidates gave an example rather than the meaning of the term hydrocarbon.

(iii) Most candidates answered this correctly.

(b) (i) The general formula of the alcohol homologous series was not well recalled. Some candidates gave no response.

(ii) A small number of candidates gave a full and complete answer to this question but generally, the reactants and conditions needed for fermentation were not well recalled. Common incorrect reactants include alcohol, oxygen, carbon dioxide ethane and ethene. Common incorrect reaction conditions were time and temperature (unqualified).

(iii) Some candidates answered this correctly but many repeated the earlier question and suggested 'fermentation' or 'to make alcohol'.

(c) (i) This question was found to be challenging. Some gave no response and many candidates gave ambiguous answers such as 'compounds with similar properties' for which it is unclear whether the properties are chemical or physical.

(ii) Most candidates answered this correctly although a significant number incorrectly used the atomic number rather than the mass number or they did not remember to include the 72 given in the table in their calculation.

Question 5

Overall, this was one of the most demanding questions on the paper. Many candidates appeared to be unfamiliar with displacement reactions and the reactivity of the halogens.

(a) (i) Most candidates answered this correctly.

(ii) Most candidates answered this correctly.

(iii) Physical state should be given as 'solid', 'liquid' or 'gas'. Some candidates gave numerical answers or descriptions of melting or boiling. The reason given should have a clear reference to whether the stated temperature is higher or lower than the melting and boiling points given. Statements such as 'it has passed the melting point' were not creditworthy. General statements about the temperature such as 'the temperature is very low' were insufficient as a reason.

(b) (i) Many candidates gave incorrect answers such as 'chlorine iodide' or 'potassium chlorine'. Other incorrect answers seen were 'water' and 'carbon dioxide'.

(ii) Few candidates answered this question correctly and some did not attempt the question. Most of those who did attempt the question did not mention relative reactivity of the halogens or simply restated the question.

(c) (i) Most candidates answered this question correctly.

(ii) Few candidates could recall the test for oxygen. Some confused the test for that of hydrogen or water. A small number gave observations more appropriate for ion tests such as 'white precipitate'.

Question 6

This was the best answered question on the paper with **(e)** being particularly well answered.

(a) Most candidates could describe properties of metals. A few candidates did not gain credit because they described chemical rather than physical properties or they gave the same property given in the question.

(b) (i) Most candidates gave the number of neutrons. Many included the number of protons. Better performing candidates were able to determine the number of electrons.

(ii) A small majority of candidates answered this question correctly. Some candidates answered using 's p d f'. Where candidates used this notation correctly, they were awarded credit but centres should note that this is not required at IGCSE and comma separated values such as 2,8,8,1 are expected.

(c) Only some candidates answered this question correctly. All the other options were chosen.

(d) Only some candidates answered this question correctly. Candidates should make it clear which substance has gained or lost oxygen during the reaction. In this particular question, it is the nickel(II) oxide which has lost oxygen not the nickel. It was not necessary to describe where the oxygen is going nor to describe the products formed.

(e) Most candidates answered this question correctly but a significant number incorrectly used the word 'metal' rather than the name of one of the four metals.

Question 7

Candidates would benefit from further practical experience in the formation and extraction of salts and the names and reactions of common acids, bases and alkalis.

(a) (i) This question was found to be challenging with only the better performing candidates able to give a creditworthy answer. Many candidates suggested the name of a different salt. A small number suggested other acids or nitrogen for the acid or gave potassium oxide or potassium neither of which are alkalis, although both will produce the correct alkali, potassium hydroxide, in water.

(ii) Most candidates answered this correctly.

(iii) The colours of thymolphthalein at different the pH values was not well known.

(iv) This question was found to be challenging and some candidates did not attempt it. A small number of candidates gave a partial answer involving heating or filtration but only a handful gave a clear description of the extraction of a dry salt from its solution.

(b) (i) Most candidates recognised that the term endothermic described energy movement but few described the movement of thermal energy from the surroundings.

(ii) A small majority of candidates recognised that the state symbol (l) is used to identify a liquid. Fewer were able to describe how the figure represented an endothermic reaction. Candidates are reminded to describe the relative energy of the reactants and the product.

Question 8

Candidates made a good attempt at these questions but often gave answers that were incomplete or did not meet the requirements to be given credit.

(a) (i) Some candidates answered this correctly but many candidates were unable to link the shortest reaction time to the most concentrated acid. All possible arrangements of the concentrations were seen.

(ii)(iii) Candidates must take care to note whether they are being asked for the reaction rate or the reaction time. Most candidates correctly identified the effect of the catalyst on reaction rate but made no mention of reaction time.

(b) (i) Few candidates recalled the products of the electrolysis of dilute sulfuric acid. Many candidates were unclear what the question required and either gave the name of the electrodes (anode and cathode) or the ions attracted to that electrode (anion and cation) rather than the chemical products. Those that gave a correct answer tended to recall the production of hydrogen, but few recalled the formation of oxygen, with sulfur or sulfur dioxide being common incorrect answers.

(ii) Most candidates identified platinum as the substance used to make an inert electrode.

(c) The general properties of solids, liquids and gases and the properties of the particles should be well known by all candidates. Although many candidates could describe the ordered arrangement of particles in a solid, many confused ‘separation’ with ‘separation techniques’. Rather than describing the particles as being closely packed, they described distillation, filtration or that they are ‘easily separated’.

CHEMISTRY

Paper 0620/32
Theory (Core)

Key messages

- Candidates should read each question carefully, so they are sure to answer the question asked.
- Candidates should be able to identify all the elements, ions and compounds named in the syllabus.
- The purity of substances and the effect of impurities on physical values was not well known. Candidates should be reminded that impurities typically lower the melting point and raise the boiling point of substances such as water. The impurities also change the points from a sharp single value to a range of values.
- Candidates should check they have answered all the questions on the paper, particularly those which require them to add to a diagram or graph and so does not have a separate answer line.
- Candidates should take care when answering comparative questions by either giving a statement about each substance or by using comparative adjectives such as higher, faster or larger.

General comments

Overall, candidates performed well on this paper and produced a wide range of marks.

Most candidates could interpret information from a table and could complete chemical equations.

Candidates must take care to read the whole question. Many questions required candidates to identify a substance which has more than one property such as **Question 1(a)(v)**, **(a)(vi)** or **Question 2(a)(i)** and the answer must satisfy all the requirements of the question.

Some questions required the candidates to make a comparison. Examples include **Question 6(c), 8(a)(ii)** and **8(a)(iii).** Candidates should either make a statement about both substances or reactions or use a comparative term e.g. ‘Silver has a high melting point and sodium has a low melting point’ or ‘Silver has a much higher melting point’.

Chemical tests in **Question 1(a)(iv), 7(c)** and **5(b)(ii)**, were not well known. It is recommended that candidates spend more time practising questions of this type and in practical chemistry.

Sometimes, candidates did not answer the question asked. For example, in **Question 8(b)(i)** many candidates renamed the electrodes rather than naming the electrolysis products.

Candidates frequently gave statements which were not creditworthy because they confused physical and chemical properties such as in **Questions 6(a)** and **6(c)**.

Most candidates recalled the role of chlorine in drinking water, but fewer were able to describe the use of boiling point to determine whether a sample was pure in **Question 3(e)**.

Questions on organic chemistry had the highest demand and candidates that performed less well either gave confused answers or did not attempt the questions at all. Few candidates were able to fully describe the process of cracking in **Question 4(e)(i)** and the reason hydrocarbons are cracked in **4(e)(ii)**.

Questions which required candidates to add to a diagram such as **Question 4(a)** were not attempted by large numbers of candidates. It is recommended that candidates tick-off or strikethrough the mark allocation for each question so that it is easy to identify the unanswered questions.

Candidates should take time to understand key chemical terms from the syllabus. Many descriptions were close to being correct but were too imprecise to be given credit. For example, in **Question 7(a)(i)**, it was clear that many candidates do not understand the distinction between an aqueous substance and a liquid.

Comments on specific questions

Question 1

Candidates should take care to read the question carefully where there is more than one part to the question. For example, **(a)(v)** required a substance that has resistance to corrosion and used as a food container and **(a)(vi)** which required both a metal and low reactivity. Parts **(a)(iii)** and **(b)(ii)** highlighted the confusion of many candidates between shells, periods, groups and outer-shell electrons.

(a) (i) Most candidates recalled nitrogen as the major component of clean, dry air. A small number suggested other gases such as hydrogen, H, or helium, He.

(ii) The majority of candidates linked the group number with the ion with a 3+ charge. A small number of candidates suggested gold, Au or barium, Ba.

(iii) This question was challenging for candidates, although it showed some discrimination between candidates of different abilities. A significant number of candidates confused the number of electron shells and the number of electrons in the outermost shell and suggested nitrogen, N.

(iv) Very few candidates recalled the flame test colour of barium, Ba. Many candidates incorrectly suggested calcium, Ca.

(v) Although a small majority of candidates answered this question correctly, many appeared to ignore the use and suggested gold, Au, for its resistance to corrosion. Zinc, Zn, was also a common incorrect answer.

(vi) Similarly to **(a)(v)**, many candidates missed part of the question and suggested a non-metal with low reactivity rather than a metal with low reactivity. Argon, Ar, and helium, He, were common incorrect answers.

(b) (i) Most candidates gave a reasonable suggestion to the meaning of monatomic. Several confused atoms, molecules or the electronic configuration of the atom rather than describing the substance or element as being composed of single atoms.

(ii) Few candidates described why helium is unreactive. Near miss answers such as ‘it contains a full shell’ were not sufficient because atoms of most other elements also contain full (inner) shell(s). It is essential that candidates are clear that it is the outer shell that is fully occupied. Many candidates incorrectly suggested that helium has an outer shell of eight electrons.

Question 2

Most candidates understood basic ideas of covalent bonding but the properties of simple molecules were less well known.

(a) (i) Most candidates were unclear what was required in this question. Some candidates simply named two different molecular compounds or described the covalent bonding present. Some candidates gave chemical rather than physical properties. The most common incorrect answers were properties of giant covalent substances.

(ii) This question was well answered.

(iii) Most candidates gave the two electrons in the covalent bond. A small number of candidates either added an extra electron around the hydrogen atom or only gave five non-bonding electrons around the chlorine. A few did not include any non-bonding electrons. Nearly all diagrams were well presented with electrons paired.

(b) Although many candidates answered this correctly, a large number repeated the question giving 'negative ion' or they gave an example of a negative ion, Cl^- or OH^-. Some candidates confused the terminology of electrolysis and suggested anode or cathode.

(c) (i) Most candidates gave a suitable use for diamond, although a few repeated the use from the question or gave a similar term such as 'decoration'.

(ii) Most candidates recalled the structure and bonding in diamond.

Question 3

Overall, there was a range of scores gained by candidates for this question. The properties of naturally occurring water, polluted water and drinking water were not well recalled or understood.

(a) Few candidates were distracted by the possibility of plastics or harmful microbes. The most common answer was 'dissolved oxygen' rather the correct answer 'calcium compounds'. Minerals are naturally occurring (inorganic) solid substances.

(b) Only a minority of candidates recalled that phosphates contribute to the deoxygenation of water.

(c) (i) Most candidates answered this correctly with only a few suggesting Na^+ which was the positive ion with the highest concentration.

(ii) The most common answers to this question were nitrogen oxide, nitrogen trioxide or nobelium. Candidates should be able to identify all the ions and compounds named in the syllabus.

(iii) Most candidates answered this correctly.

(d) (i) Few candidates could describe sedimentation as a process used to separate solid particles from the water or to allow the insoluble solids to settle at the bottom of a water tank. Many gave imprecise answers such as 'to purify water' or they confused the process with chlorination and suggested that it was to 'make it safe to drink'.

(ii) This question on water purification was better known and most identified the need to kill microorganisms in the water. A few incorrectly suggested that it was to remove the microbes or was to improve taste. Some suggested 'kill impurities' which was too ambiguous.

(e) Few candidates answered this question correctly. Many described processes that would produce pure water such as distillation. Others described boiling water to dryness and then examining the container for a residue.

Both an experimental method which described the heating of water to its boiling point and comparison of this value with the known value for pure water (100 °C) were needed. A small number suggested the boiling point of pure water to be 0 °C. The time taken for water to boil was not creditworthy.

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

Question 4

Questions on organic chemistry are often found to be demanding. Although most candidates answered **(a)(ii)** correctly most of the other question parts showed a range of scores for this topic.

(a) (i) In common with other years, many candidates did not attempt this question. Candidates should practice answering questions which require them to add detail or a circle to a figure or diagram.

Many of those who did answer the question circled the –COOH group rather than the hydroxyl, –OH group of the alcohol.

(ii) Most candidates answered this correctly but there appeared to be a greater number than in previous years who gave a formula type which was not a molecular formula.

(b) A greater number of candidates than in previous years incorrectly used atomic numbers rather than mass numbers for the elements. A small number of candidates correctly calculated the masses for the hydrogen and oxygen but did not add up the individual values correctly.

(c) Few candidates gave a fully correct word equation. Many gave answers such as 'ethanol oxide' or 'hydrogen' or the ambiguous 'carbon oxide'.

(d) (i) Most candidates identified the correct homologous series.

(ii) Many candidates did not know what the term 'general formula' meant and gave molecular formulae. A few candidates did not attempt this question.

(iii) Most candidates identified the correct trend from the data.

(e) (i) A small number of candidates gave full and complete descriptions of cracking. Most candidates described the cracking of ethene, or ethane rather than a reaction to produce ethene. Many candidates appeared to confuse the term cracking with the 'pop' from the test for hydrogen gas.

(ii) The use of cracking to form ethene was given in the introduction to the question so was not accepted as a reason. Candidates should be reminded that the purpose of cracking is to produce more of the smaller hydrocarbon chains, which are in greater demand, and to produce more alkenes.

Question 5

This was one of the most demanding questions on the paper.

(a) (i) This question was demanding because the candidates needed to consider the melting point of iodine as well as the boiling points of bromine and astatine. Many candidates incorrectly gave a boiling point which was lower than its given melting point.

(ii) This question was found to be more straightforward and most candidates answered it correctly.

(iii) Many candidates found this question challenging.

(b) (i) Many candidates rearranged the chemical names of the reactants to produce incorrect answers such as 'chlorine bromide' or 'lithium chlorine'.

(ii) A few candidates did not attempt this question and a few gave a correct answer. Many did not mention relative reactivity of the halogens and often restated the question.

(iii) Few candidates could recall any part of the test for chlorine. Many thought that it gave a green flame in a flame test or confused the test for chlorine with that for chloride ions.

(c) Although this equation was slightly more demanding than in other years, most candidates achieved at least partial credit.

Question 6

This was the best answered question on the paper with **(a)** and **(d)** being particularly well answered.

(a) Most candidates could describe properties of metals. A few candidates did not gain credit because they described chemical rather than physical properties required or they gave the same properties given in the question.

(b) (i) Most candidates calculated the number of neutrons and protons correctly. Fewer were able to calculate the number of electrons in the ion, often suggesting 47 or occasionally 48.

(ii) This question was generally well answered although candidates who performed less well overall found it particularly difficult.

(c) Although some candidates gave good answers, many did not give a comparative answer. Answers such as 'silver has a high melting point' is insufficient to describe the difference between silver and sodium unless the candidate also states that sodium has a low melting point or that silver has the higher melting point. A small number of candidates described differences in chemical rather than physical properties.

(d) Most candidates performed well on this question. Of those who did not, a significant number used the word 'metal' in place of one of the metals listed.

(e) Few candidates answered this question correctly. Candidates should make it clear which substance has gained or lost oxygen during the reaction. In this particular question it is the copper(II) oxide which has lost oxygen. It was not necessary to describe where the oxygen is going nor to describe the products formed.

Question 7

The properties of acids and bases and the formation of salts was not well recalled by the candidates. Candidates could perhaps benefit from further practical experience in the formation and extraction of salts and further study on the names of common acids, bases and alkalis.

(a) (i) Although the majority of candidates answered this correctly, it was clear from candidates who wrote a longer answer that the meaning of the state symbol '(aq)' is not well understood. Candidates must understand that the state symbol (l) for liquid represents a single substance whereas (aq) represents a substance dissolved in water. Liquid and aqueous are not interchangeable and the substance is dissolved so 'mixed with water' or 'water is present' is not sufficient.

(ii) Filtration was the most common and correct answer but many incorrectly suggested other separation techniques such as distillation or crystallisation.

(b) (i) This question was one of the least well answered questions on the paper. Many candidates suggested the name of a different salt. A small number suggested other acids or nitrogen for the acid or gave sodium oxide or sodium neither of which are alkalis, although will both produce the correct alkali, sodium hydroxide, in water.

(ii) This is an unknown equation to most candidates and is unusual in being an ionic equation at this level. Some candidates suggested H^- or O_2 or a neutral OH but some candidates did not attempt the question.

(iii) Most candidates gave the correct answer or a near miss. Candidates should be reminded that it is thermal energy that is released to the surroundings in an exothermic process.

(iv) Many candidates were unclear how to use the figure to answer the question. Many thought it represented the amounts of reactant and product, and some repeated their answer to **(b)(iii)** without any reference to the figure at all.

(c) Many candidates identified red as the colour of methyl orange at pH 2 but few recalled the colour at pH 12. There appeared to be confusion of the colours of methyl orange with those of universal indicator.

Question 8

Candidates made a good attempt at these questions but often gave answers that were incomplete or did not quite meet the requirements to be awarded credit. Candidates should complete further practice questions comparing rates and reaction times.

(a) (i) Candidates found it difficult to match the longest reaction time to the lowest concentration acid. All possible arrangements of the three concentrations were seen.

(ii) Questions on this topic may ask candidates to describe the change in reaction rate or the change in reaction time. Candidates should take care to note which is asked. Many candidates recognised that the rate would be faster but did not state that reaction time would shorter. The statement 'the reaction time is short' is not sufficient because the answer required a comparison of the reaction time before and then after a change in reaction conditions.

(iii) This question showed the same errors as **(a)(ii)**.

(b) (i) A range of scores was seen for this question. Candidates who performed less well often confused what was required and gave the name of the electrodes (anode, cathode) or the ions that were attracted to each electrode rather than the products.

(ii) Most candidates identified graphite as the substance used to make an inert electrode.

(c) The general properties of solids, liquids and gases and the properties of the particles should be well known by all candidates. Although many candidates could describe the random motion of particles in a gas, many confused 'separation' with 'separation techniques'. Rather than describing the particles as being far apart, they described distillation or that they are 'easily separated'.

CHEMISTRY

Paper 0620/33
Theory (Core)

Key messages

- Questions requiring simple answers to calculations were well answered as were questions involving balancing equations. Candidates were able to easily calculate the relative molecular mass of a given compound as in **Question 4(b)**.
- Candidates were easily able to put the metals in order of their reactivity as in **Question 6(d)**.
- Questions where candidates had to predict values for melting points and atomic volumes were answered much better this year. Candidates were able to answer these prediction questions very well using the given data from the table as in **Question 5(a)(i)** and **(ii)**.
- The answering of chemical test questions was found to be challenging. The candidates' answers showed many large gaps in their knowledge. Candidates struggled with 'forms an ion that gives a red-brown precipitate on addition of aqueous ammonia' as in **Question 1(a)(v)** and the other chemical test questions seen on this paper.
- Organic questions were answered well this year, and some candidates could draw the structures of organic compounds. Some candidates could 'draw the displayed formula for a molecule of ethanol' as in **Question 4 (d)(ii)**.
- Questions where the candidate had to match an element to a given statement were not answered as well as in previous years.

General comments

Many candidates tackled this paper well, showing a good knowledge of core chemistry. Good answers were shown throughout the paper to several different questions. Most candidates found parts of every question challenging. It was evident that many candidates are now using past papers as part of their revision programme, but more revision is needed on some aspects of this syllabus.

Misinterpretation of the rubric happened in some cases. The most common misinterpretation was in **Question 8(b)(ii)** which asked the candidates to 'describe the arrangement, motion and separation of the particles in liquid magnesium chloride'. Some candidates thought that the word 'separation' meant a separation technique used for a mixture and so did not achieve credit here. Candidates also struggled with the longer question about the manufacture of ethanol using an addition reaction. Many candidates did not know the correct answers to this question and could not recall them. Lots of candidates thought the process used was fermentation and gave the substances and conditions for this, which was incorrect. Many candidates left this question blank. The processes used to manufacture ethanol is a topic that needs to be revisited many times during the revision of this course.

The balancing of equations was good and definitions from across the syllabus were reasonably well answered.

Questions with the command word 'deduce' and 'predict' were answered well by many candidates and many were able to justify their response to the prediction. Data handling type questions were answered better this year. However, a few candidates made slight mistakes and were not precise enough when answering these types of questions.

The standard of English was very good. Some candidates need to be more explicit when writing about certain concepts and not use the words 'it' and 'they' to answer questions. Some better performing candidates wrote their answers as short phrases 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 found this first question the hardest question on this paper. There were many incorrect answers seen for most of the parts. Candidates especially struggled with parts **(a)(ii)** and **(a)(v)** which were the two chemical test questions. This is a part of the syllabus that candidates should learn and revise more thoroughly.

(a) (i) Many candidates struggled with this first question. Fe and Ag were very common errors seen here.

(ii) Candidates found this chemical test question particularly challenging. There were not many correct answers seen. K was a very common incorrect answer.

(iii) This question was answered well. A few incorrect answers of N were seen.

(iv) Candidates answered this question very well.

(v) Candidates found this chemical test question particularly challenging. There were not many correct answers seen. Zn was a very common incorrect answer.

(vi) Candidates did well on this question. However, Li and K were common errors seen here.

(b) Candidates did well on this question. Most could state that the elements given were in the 'same group' or in 'Group I'. However, fewer candidates could state they all had 'the same number of electrons in their outer shell'. Stating that the elements were all in the same period was a common incorrect answer.

Question 2

Candidates found this question particularly hard. Candidates especially found the naming of the polymer challenging as in **(a)(iii)** and stating the 'two physical properties of ionic compounds' as in **(b)(i)**. Candidates were able to complete the dot-and-cross diagram in **(a)(ii)**.

(a) (i) Most candidates answered this question correctly. However, incorrect very high or very low percentages were also seen.

(ii) Candidates did very well on this dot-and-cross diagram. Most could draw the bonding pairs of electrons between the oxygen and hydrogen atoms and the two lone pairs of electrons on the oxygen atom. However, the most common error was adding extra electrons on the hydrogen atoms.

(iii) Many candidates struggled with this question and could not name the correct polymer.

(iv) Most candidates answered this question correctly.

(b) (i) Candidates found this question particularly challenging. Some could state one correct physical property but not two of ionic compounds. A very common error was stating that ionic compounds can conduct electricity but then not being specific enough as to when they can conduct electricity.

(ii) Most candidates answered this ionic bonding question correctly.

Question 3

Candidates found this question slightly easier than **Questions 1** and **2**. They did well on the data handling question plus they could easily balance the given symbol equation. Part **(d)** caused the most problems and only a very small number of candidates achieved full credit on this question. The treatment of the domestic water supply is a topic that needs to be revised more.

(a) Many candidates performed well here and circled the correct answer. There were candidates that thought the gas that is essential for aquatic life was 'nitrogen'.

(b) Most candidates could correctly link the harmful substance to the correct effect.

(c) (i) This question was very well answered. A few candidates did not read the question correctly and answered with the highest concentration instead of the lowest.

(ii) Candidates found this question challenging and could not name the ion correctly. Very common incorrect answers were sulfur oxide or sulfate oxide.

(iii) Most candidates could correctly answer this simple calculation question.

(d) Candidates found this question challenging and only a very small number achieved full credit. However, many candidates did state 'chlorine' and 'kill bacteria'. Only the better performing candidates overall could correctly name the second substance with a reason.

(e) This was one of the most well answered questions on this paper. Most candidates could correctly balance the given equation.

Question 4

Candidates found this organic chemistry question challenging. Candidates struggled especially with **(d)** on the manufacture of ethanol. However, candidates were able to easily calculate the relative molecular mass of the given compound as in **(b)**.

(a) (i) Some candidates struggled to draw a circle around the carboxylic acid functional group and instead drew a circle around the alcohol functional group. There were quite a few no responses here.

(ii) Candidates did well on this question. The elements can be placed in any order, but the numbers must be subscript and not superscript.

(b) Most candidates were able to calculate the relative molecular mass of the organic compound correctly.

(c) (i) This question was found to be challenging. Some candidates struggled to name the required homologous series. Many different incorrect answers were seen with some candidates just naming another alcohol in this homologous series.

(ii) Candidates struggled with this question and there were a few no responses. Some candidates got mixed up with the general formulas of other homologous series in this syllabus and gave the general formula of an alkane instead.

(iii) Most candidates answered this question correctly and could state the required trend.

(d) (i) This question was found to be challenging and there were a lot of no responses. Candidates did not know the substances and conditions needed to manufacture ethanol by an addition reaction. Some candidates got this manufacturing process mixed up with the fermentation manufacturing process and so answered with the incorrect substances and conditions for fermentation.

(ii) For this question the strongest candidates were the only ones that could draw the correct structure of ethanol. However, more candidates are correctly drawing the displayed formulas of organic molecules, than in previous years.

(iii) Most candidates were able to name the toxic gas produced when ethanol undergoes incomplete combustion.

Question 5

This question discriminated well between candidates. Candidates did very well on **(a)(i)** and **(ii)**. Candidates found **(b)(ii)** particularly challenging.

(a) (i) This was a very well answered question. Most candidates could predict the correct melting point of astatine. It is better not to state a range here just in case one of the values is outside the allowable region.

(ii) This was a very well answered question. Most candidates could predict the correct atomic volume of fluorine. Again, it is better not to state a range here just in case one of the values is outside the allowable region.

(iii) This question was found to be challenging. Many candidates thought that the correct physical state was 'gas'. They had got mixed up with what the minus signs mean. Candidates who did get the correct state were then not able to compare the stated temperature to the melting point and boiling point given in the question for the reason.

(b) (i) This question was generally well answered by most candidates. Errors that were seen were candidates using 'iodide' instead of 'iodine' and 'sodium chlorine' instead of 'sodium chloride'. However, this question was answered better than in previous years.

(ii) Candidates found this question the hardest on this paper with few correct answers seen. Common incorrect answers were 'bromine is less reactive than chloride' and 'bromine is less reactive than sodium chloride solution'.

(c) Most candidates answered this question correctly. The most common incorrect answer was '2O' instead of 'O_2'.

(d) This question was found to be challenging. Most candidates could not name an anhydrous compound used to test for water and did not know the colour of the compound after water is added.

Question 6

Candidates found this question the least challenging on this paper. They did very well on most of the questions especially **(a)** and **(d)**.

(a) This was a very well answered question. Most candidates could recall at least two of the required three properties of metals. A few candidates used 'malleable' or 'ductile' as one of their answers. They did not gain credit for these as they were given as part of the question.

(b) (i) Most candidates could deduce the number of electrons, neutrons and protons in the species shown. The number of electrons in the copper ion caused some problems for a few candidates.

(ii) Most candidates answered this question correctly.

(c) Most candidates could answer this question correctly and could recall that transition elements can often act as catalysts.

(d) Candidates found this question the least challenging on this paper. They could easily put the four metals in order of their reactivity.

(e) Candidates performed less well on this question and most candidates found it a challenging question. Many candidates were not specific enough with their answers. Few candidates could explain correctly how the given equation shows that manganese(IV) oxide is reduced. 'Manganese has lost oxygen' and 'reduction is loss of oxygen' were the most common incorrect answers.

Question 7

Most candidates were able to state the method used to separate the excess solid zinc oxide from the reaction mixture and were able to define the term exothermic. However, many candidates struggled to explain how the given diagram showed that the reaction is exothermic.

(a) (i) Most candidates could add the correct state symbol for water at room temperature.

(ii) Most candidates answered this question correctly. Common incorrect answers were 'distillation' and 'crystallisation'.

(iii) Candidates found this question challenging. They struggled to describe how to make dry crystals of zinc chloride from an aqueous solution of zinc chloride. Many candidates just used 'heat' but did not state correctly that heat needed to be applied until the 'point of crystallisation' or 'until crystals were seen'. Most candidates then forgot to 'filter out the crystals' or 'dry with filter paper'.

(b) Most candidates could choose from the list the ion that is present in all acids.

(c) (i) Candidates did exceptionally well on this definition question.

(ii) This question had the most no responses on this paper. Candidates need to make sure that they answer all the questions that have a mark by the side of them. However, candidates who did attempt this question answered it very well.

(iii) This question was found to be challenging by many candidates. Errors seen were where candidates did not compare the energy of the reactants to the energy of the products but just stated that the reactant is greater than the product or energy decreases or more energy was released at the end of the reaction.

(d) Most candidates knew the colour of litmus at pH 2 and pH 12.

Question 8

Candidates found the last question on this paper very challenging. They particularly struggled on the very last question which was to 'describe the arrangement, motion and separation of the particles in liquid magnesium chloride'.

(a) (i) Candidates found this question challenging and got mixed up with which acid concentration went with which time. The higher the concentration of acid the less time taken for the reaction to finish.

(ii) Many candidates answered this question correctly. The most common error was to give an answer that was not comparative such as 'takes a long time'. Some candidates also confused time with the rate of reaction and stated incorrectly that 'rate of reaction is slower'.

(iii) Candidates found this question slightly harder. The most common error was to give an answer that was not comparative such as 'takes a long time'. Some candidates also confused time with the rate of reaction and stated incorrectly that 'rate of reaction is slower'.

(b) (i) For this question, a lot of candidates could name the product formed at each electrode but some did get 'chloride' confused with the correct 'chlorine'. A few candidates mentioned incorrectly that ions were being formed at the electrodes.

(ii) Candidates found this last question very challenging and many struggled with describing the arrangement, motion and separation of the particles in liquid magnesium chloride. Some candidates got 'motion' and 'separation' mixed up while others thought that the 'separation' part of the question was to do with the separation of mixtures and wrote down incorrectly 'fractional distillation' or 'filtration'.

CHEMISTRY

Paper 0620/41
Theory (Extended)

Key messages

- Where candidates are required to select an answer from a set of possible choices, such as **Question 1**, they should be encouraged to make an attempt 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 2(e)(ii)**.
- 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 has 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 deducing and drawing condensation polymers given unfamiliar monomers.
- Candidates should use the syllabus value for the Avogadro constant and not 6×10^{23}.

General comments

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

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

Comments on specific questions

Question 1

(a) This question was answered well with most candidates recalling that neutralisation occurs between an acid and an alkali.

(b) This was well answered with candidates realising that reversible reactions can reach equilibrium.

(c) This question was more challenging and many candidates opted for combustion or thermal decomposition. The confusion being that gases are formed so particles have left their fixed position. However, the key idea was that the particles were still touching once they had left their fixed positions so a liquid must be formed. Hence, the only possible answer was melting.

(d) The candidates found this question challenging. While the majority recognised that melting was a physical change, fewer could state that diffusion was a physical change with the most common incorrect answers being combustion, roasting or thermal decomposition.

(e) The majority of candidates were able to recall that diffusion was caused by the collision of gas particles.

Question 2

(a) The term nucleon was well known with the most common error being to say 'same protons but different neutrons'.

(b) This was answered well by the majority of candidates who knew that the period number is the same as the number of occupied electron shells. A few candidates thought that the period number represented the number of electrons in the outer shell.

(c) The majority of candidates knew the electronic configuration of silicon was 2,8,4. Fewer candidates appreciated that the chloride ion had gained an electron to have a full outer shell with a significant number of candidates giving 2,8,7 as the electronic configuration for Cl^-. A few candidates gave the correct answer using 's p d' notation. Where candidates used this notation correctly, they were awarded credit but centres should note that this is not required at IGCSE and comma separated values such as 2,8,8,1 are expected.

(d) The majority of candidates were able to correctly work out the numbers of neutrons and electrons in atoms and ions. While most candidates gained full credit for ${}^{69}_{31}Ga$ it should be noted that the following are not creditworthy due to the incorrect placement of the mass and atomic number: ${}^{31}_{69}Ga$, ${}^{31}_{69}Ga$, and ${}^{69}_{31}Ga$.

(e) (i) Candidates found the definition of the term isotopes challenging. Candidates should be able to recall the syllabus definition of 'different atoms of the same element that have the same number of protons but different numbers of neutrons'.

(ii) Many of the better performing candidates were 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. 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 203 and 205 to gain 204 without using the percentage abundances, answers of 204 seen without working out and correctly calculated answers of 204. 4 then incorrectly rounded to a final answer of 204 due to lack of understanding of the requirements of one decimal place.

(iii) Many candidates appreciated that isotopes have the same chemical properties because they have the same number of electrons. The most common incorrect answers included 'because they have the same number of protons' and 'because they are the same element'.

Question 3

(a) Candidates were asked to complete the equation for the formation of copper(II) sulfate. Almost all the candidates could recall that the other product of the reaction was water. State symbols were less well known with the most common error being $H_2SO_4(l)$ rather than $H_2SO_4(aq)$.

(b) Most candidates realised that the copper oxide would be in excess when no more solid dissolves. A few candidates stated that there would be a blue solution formed. While this is a correct observation it would not tell them when the copper oxide was in excess, so this observation was not creditworthy. Some candidates stated there would be no more effervescence, showing some confusion with the use of copper(II) carbonate to make copper(II) sulfate.

(c) Most candidates knew that the reaction mixture had to be filtered to remove the excess copper oxide. A small number of candidates incorrectly stated that it was evaporation or fractional distillation.

(d) (i) The syllabus definition of 'a substance that is chemically combined with water' for the term hydrated was not well known with most candidates writing imprecise answers such as 'when water is added', 'contains water' or 'has the presence of water'.

(ii) The formula of hydrated copper(II) sulfate was not well known. Only the better performing candidates could recall the formula as $CuSO_4 \cdot 5H_2O$. The most common incorrect answers included $CuS \cdot XH_2O$, $CuSO_4 + 5H_2O$, $CuSO_4 \cdot H_2O$ and $CuSO_4 \cdot 6H_2O$.

(iii) Candidates found the method of crystallisation challenging.

Several candidates described how to prepare an aqueous solution of copper(II) sulfate which was unnecessary. Some candidates chose to heat to constant mass. Filtration at the start is unnecessary because there is no reason to filter a solution. The main omissions were giving no indication of when to stop heating, not leaving the crystals to cool but just leaving to dry, to miss out the heating of the solution and to state that the water should be evaporated.

(e) (i) Most candidates appreciated that copper(II) sulfate conducts due to mobile ions. A common error is to refer to 'free' ions but the reason that copper(II) sulfate conducts is that the ions are able to move. Candidates who performed less well thought that it conducted due to the movement of electrons.

(ii) Most candidates knew that graphite electrodes are inert and that they were electrical conductors. Common responses that did not gain credit were 'high melting point', 'cheap', 'insoluble' or 'can conduct' (which could have been the conduction of heat).

(iii) Candidates found this question very challenging. Some candidates described the formation of copper e.g. pink-brown solid. 'Becoming blue' was another common incorrect answer. The correct answer had to make it clear that the electrolyte turned colourless.

(iv) While most candidates knew that copper was produced at the electrode, the question asked for an observation so stating 'copper seen' is not an observation. The correct answer of pink deposit was rarely seen with common incorrect answers being 'bronze' (which is not a colour); 'solid', 'pink metal' or 'copper metal'.

(v) Candidates found this question very challenging. O_2^- was very commonly seen as the only species on the left-hand side. Those who realised that OH^- was the ion that was discharged usually got the ionic half-equation completely correct.

(vi) The candidates found describing the differences between the two experiments challenging. Many candidates had the idea that the anode dissolved or became smaller but fewer appreciated that the colour of the copper(II) sulfate would remain blue. Some candidates said that the mass of the anode would get smaller, which while being true is not an observation. Some candidates said that the cathode would get larger, but this did not gain credit as the cathode would get larger in both experiments so is not a difference. Others said that the electrode would dissolve without specifying the anode.

Question 4

(a) (i) Common errors for the oxidation numbers included the incorrect representation of an oxidation number e.g. 5+ (which represents an ionic charge) instead of +5 or omitting the sign for the oxidation number altogether. Roman numerals should not be used for oxidation numbers. A common mistake for N in $Mg(NO_3)_2$ was +6. Most candidates could state the oxidation number on NO_2 was +4.

(ii) A considerable number of candidates thought that magnesium was oxidised in this reaction and not oxygen.

(iii) The candidates answered this calculation well. Common errors included the use of 134 for the M_r of $Mg(NO_3)_2$ (use of only one nitrogen) and the use of 24 dm^3 instead of 24000 cm^3.

(b) This was answered extremely well. Both dots and crosses were almost always used correctly. Charges on the ions were almost always correct. Good practice was largely followed in drawing the outer-shell electrons in pairs.

(c) This was also answered extremely well. Both dots and crosses were almost always used correctly. Non-bonding electrons on one or two of the oxygen atoms were occasionally missing.

Good practice was largely followed in drawing the non-bonding electrons in pairs.

Question 5

(a)(i) A common incorrect response was carbon as the substance that combines with hydrogen in a fuel cell rather than oxygen.

(ii) Candidates tended to write imprecise statements such as less polluting, cheap or renewable. Answers should consider the chemistry of the fuel cells such as water being the only product as the key advantage, and hydrogen being hard to store as the key disadvantage. A number of candidates said a disadvantage was that hydrogen is flammable, but gasoline is also flammable, so this is a disadvantage of both types of fuel cell.

(b) (i) Fractional distillation as a method of separating petroleum into its different components was well known.

(ii) Cracking as a method of converting large molecules into small molecules was also well known.

(c) Candidates found this much more challenging than the other calculations on the paper. The correct answer was occasionally rounded to only two significant figures. All the values in the question are to three significant figures which is a good indication that three significant figures are required in the answer. Many candidates multiplied the Avogadro constant by 44 or 48. If the number of moles were correctly calculated the majority of candidates then multiplied the number of moles by the Avogadro constant without appreciating that there were 8 hydrogen atoms in the molecule thus finding the number of ester molecules rather than the number of hydrogen atoms in the ester molecule. The most common answer was 1.09×10^{23} which gained some credit.

(d) This question was done well by the majority of candidates but some confused carbon for hydrogen and gave all the answers using molecules containing six carbon atoms rather than six hydrogen atoms.

(e) (i) Hydrocarbons must be referred to as compounds or molecules. It is essential to mention that hydrocarbons only contain hydrogen and carbon.

(ii) Those who referred to double bonds often omitted to mention that the double bonds were between carbon atoms. Candidates should be mindful not to repeat words used in the stem of the question as this will not be creditworthy. A handful of candidates tried to make the term too specific by referring to polymerisation. Candidates should use the syllabus definition for unsaturated which is 'an unsaturated compound has molecules in which one or more carbon–carbon bonds are not single bonds'.

(iii) Many candidates did not recall the catalyst. Common incorrect answers included zinc, transition metals, zeolite, acid and manganese(IV) oxide.

(iv) This question was answered well by most candidates recalling that an addition reaction only forms one product. Some candidates discussed the addition of hydrogen across the double bond but this is not the definition of an addition reaction.

Question 6

(a) Most candidates could recall that natural polyamides were made by condensation.

(b) The majority of candidates knew that natural polyamides are proteins.

(c) This question was answered well by many candidates. Common errors included not showing the bond in displayed formula of the –O–H group or using H for 'R' in the amino acid. The question asked for the structure of a general amino acid and the use of H made the amino acid into the specific amino acid alanine.

(d) This was a challenging question to test the understanding of condensation polymer formation. Many candidates did not attempt this question or copied out sections of the monomer units given in

the question. The question asked for displayed formulae and so the amide link should have been fully displayed. Many candidates did not appreciate that polymers have continuation bonds. Other frequently seen errors were omitting hydrogen atoms from the nitrogen groups of the amide groups, connecting amino groups or carboxyl groups to the rest of the molecule by the H atom and thus creating divalent hydrogen atoms i.e. –HN– or –HNOC– or drawing a polyester using a ester repeat unit. Candidates should practice deducing and drawing the structure of polyamides from given monomer units.

(e) Many candidates were able to recall the equation for R_f. Common errors included putting the equation upside down e.g. R_f = distance travelled by solvent ÷ distance travelled by solute or stating distance of solvent from the baseline without appreciating that it is the distance the solvent moved that is a key factor.

(f) (i) The majority of candidates had an understanding that the pencil line was drawn in graphite as it is not soluble.

(ii) This recall term from the syllabus was not well known. Only the better performing candidates could recall the term locating agent. Most candidates stated imprecise terms such as indictor or dye.

(iii) Most candidates were able to state that there were only two spots as the dyes had similar solubilities or the same R_f value. Several candidates said that it was because one of the substances was not soluble. This is incorrect as there is no dot on the baseline indicating that all the amino acids have moved so are therefore soluble.

(iv) This was answered correctly by the majority of candidates who appreciated another solvent should be used to separate the amino acids. The most common misconception was to do the experiment again using three separate chromatograms or put three separate spots on the same chromatogram.

CHEMISTRY

Paper 0620/42
Theory (Extended)

Key messages

- In questions, such as **Question 1**, where the answer is one of a set of given letters, candidates should be encouraged to make a best attempt guess if they are unsure of the answer as there is no penalty for incorrect answers.
- There is no need for candidates to be taught beyond the requirements of the syllabus. This was apparent in **Question 6(b)(ii)** where many candidates attempted to give the full formula of PET rather than the simplified box notation shown in the syllabus. Similarly, the exact nature of intermolecular forces such as Van der Waals forces, induced dipoles or London dispersion forces are not required.
- Calculations were done well generally, but candidates who performed less well tended to omit their working. If an M_r needs to be determined as part of a solution, the M_r needs to be given as a stated value and not left as an incomplete sum of A_r values.

General comments

There appeared to be sufficient time for all questions to be answered.

Some candidates were still not familiar with some of the newer content of the new syllabus.

If a single answer is asked for, two or three responses 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.

Candidates should write clearly and legibly enough so their answers are unambiguous. If a mistake is made, candidates should strike through their unwanted response and rewrite a new response.

Comments on specific questions

Question 1

The answers for **(a)** to **(i)** were selected from the list in Table 1.1.

The best answered questions were **(b)** and **(h)**. The hardest were **(c)** and **(f)**.

Many candidates omitted sub-questions. Candidates should be encouraged to make a best attempt guess if they are unsure of the answer as there is no penalty for incorrect answers.

Question 2

(a)(b) Most candidates knew bauxite was the name of the main ore of aluminium in **(a)** and cryolite was added to reduce the operating temperature in **(b)**. Phonetically correct misspellings were allowed but answers such as baux**ide**, cryol**ate** and cryol**ide** were not.

(c) Candidates continue to show a misunderstanding about conductivity as the majority of candidates referred to electrons. Of those who knew that ions were responsible for conductivity of molten compounds, many candidates omitted the key fact that ions must be mobile for conductivity to occur. Vague phrases such as ‘free ions’ or ‘delocalised ions’ received no credit.

(d)(i) The main error for was to balance the ionic half-equation with $2e^-$.

Nearly all candidates knew the ionic half-equation for the reaction at the cathode involved Al^{3+} ions, but many were unable to give the complete ionic half-equation. Frequently seen errors included: $Al^{3+} + 3e^- \rightarrow 3Al$; $Al \rightarrow Al^{3+} - 3e^-$ or half-equations showing aluminium ions with incorrect charges.

(ii) Only a few candidates stated the oxidation occurring was due to oxide ions losing electrons.

(iii) Most candidates knew that oxygen reacted with the electrode/anode but many neglected to also specify that the anode was made of carbon/graphite. Candidates who performed less well assumed incorrectly that the reason was due to relative reactivities of oxygen versus carbon dioxide.

(e) Section 9.2.1(c) of the syllabus states that 'aluminium is used in food containers because of its resistance to corrosion'. Very few candidates were able to recall this. Suitable alternatives such as 'aluminium has a protective oxide layer' were allowed. Common errors included 'good conductor of heat' or other properties applicable to all metals rather than specific to aluminium such as 'malleable'.

(f) Many candidates were able to draw correct a dot-and-cross diagram of ions in an ionic bond. Even candidates who performed less well overall were able to insert the charges on the ions.

The most commonly seen error was to show both sets of ions as atoms i.e. Al with the configuration of 2,8,3 and F with the configuration of 2,7.

Question 3

(a) Nearly all candidates appreciated that the attraction between the particles must be weak; many candidates omitted to state that the particles involved were molecules.

The common phrase 'weak intermolecular forces' gained full credit, but incorrect statements such as 'weak covalent bonds' did not gain the credit available for the particles involved as covalent bonds are formed between atoms.

(b) The equation was poorly done. Many candidates assumed S was diatomic or Cl was monatomic, and two very common incorrect responses were $S_2 + Cl_2 \rightarrow S_2Cl_2$ or $2S + 2Cl \rightarrow S_2Cl_2$.

(c) The dot-and-cross diagram of SCl_2 was done very well, and the majority of candidates answered this correctly. Occasionally, diagrams showing all dots or all crosses were seen and some diagrams omitted non-bonding electrons, particularly from the chlorine atoms.

(d) This question tested the ability of a candidate to realise lowering the concentration of the product could be achieved by shifting the equilibrium to the left. Candidates who performed less well struggled with this concept. Other candidates were able to state reducing the concentration of either reactant, or both, would bring about this change. The key piece of information that the (forward) reaction was exothermic was not acted upon that well, and relatively few candidates suggested increasing the temperature.

Weaker responses of 'decrease the pressure' did not realise that the number of moles of reactants equalled that of products.

(e)(i) Section 5.1.5 of the syllabus defines activation energy as 'the minimum energy that colliding particles must have to react'. Very few candidates gave this exact definition. Most candidates opted for simplified or incomplete definitions such as 'the minimum energy for a reaction to take place'.

(ii) The symbol for activation energy, E_a, was well known.

(iii) Most candidates coped well with and knew the effect of changing the conditions stated, but the fact that the most common errors related to knowledge of how the proportion of collisions changed upon increasing temperature and addition of a catalyst suggests that many candidates are still uncertain about particle behaviour during reactions.

(f) Many candidates found this question challenging. Many responses gained no credit, often as a result of describing the oxidations only in terms of electron transfer with no attempt to consider oxidation numbers, despite the question asking for this. The other common error was to confuse oxidation number with ionic charges.

Candidates should be taught that oxidation numbers are whole numbers with a plus or minus sign in front, with the exception of 0. Stating Roman numerals in names such as iron(II) chloride is not sufficient as the oxidation number of the element.

Question 4

(a) The state symbols for this precipitation reaction were generally well known although incorrect use of capital letters as in 'Aq' was not uncommon.

(b) Silver nitrate as an alternative aqueous silver salt was frequently seen and was expected as this is what section 7.3.2(b) of the syllabus leads to. However, many candidates thought that if silver ethanoate was soluble then so should silver methanoate, propanoate and butanoate.

(c) A high proportion of candidates answered this question correctly.

(d) Only the better performing candidates were able to recall the colour of silver bromide. Candidates should avoid giving two colours such as white/cream or yellow/cream as this involves the colours of silver chloride and silver iodide.

(e) Many candidates gained full credit for this question. The number of moles of AgBr was most frequently incorrect, as some candidates assumed incorrectly that 0.0100 moles of CH_3COOAg added to 0.0100 moles of NaBr would give 0.0200 moles of AgBr.

Candidates should be reminded that it is good practice to fully evaluate their calculations of M_r and also to state that this number is the M_r. Without showing full working out, it is often not possible to award credit for an error carried forward.

(f) The name of the salt dissolved in the filtrate, sodium ethanoate, was frequently known although insoluble silver bromide was often seen, suggesting these candidates could not distinguish between 'filtrate' and 'residue'.

(g) (i) Most candidates knew the missing step was lack of rinsing, although many candidates opted to state that the precipitate should be heated to constant mass.

(ii) Only the better performing candidates knew that it was the presence of sodium ethanoate which caused the greater mass of residue.

(h) (i) Most candidates were able to gain full credit. Barium oxide was a common incorrect answer as was barium sulfate.

(ii) Some candidates gave incorrect formulae including many who used the wrong symbol for barium, often B or Br.

Question 5

(a) This was well answered with most candidates identifying petroleum (or crude oil) as the source of alkanes used for cracking.

(b) According to section 11.5.2 of the syllabus, the conditions used for cracking are a high temperature and a catalyst. No specific temperature or catalyst is given. Many candidates opted to give specific temperatures and attempted to name the catalyst.

(c) (i) Better performing candidates gained full credit, but many candidates who knew the correct molecular formula of but-1-ene did not form three molecules of it. Thus, the most common incorrect product combination was $C_4H_8 + C_8H_{18}$. If these candidates had referred to the information given in the question carefully, they may have amended their answer to form a total of four product molecules.

(ii) Although 'thermal decomposition' was the expected answer many candidates simply gave 'decomposition'.

(d) (i) Most candidates knew poly(propene) – brackets were not required – was the polymer formed from propene. Candidates should be reminded that handwriting needs to be unambiguous because in many cases 'polypropane' and 'polypropene' were indistinguishable.

(ii) Many candidates assumed that three units of polymer formed from propene would have three lots of three carbon atoms, (i.e. 9 carbon atoms) in the carbon chain. Of those candidates who realised that three units of polymer would be formed by breaking three C=C bonds to give a carbon chain of six carbon atoms, most went on to insert three methyl side groups in the correct positions.

(iii) Most candidates knew alkenes such as propene underwent addition polymerisation.

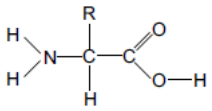
Question 6

(a) (i) This was generally well answered. The most common error was exclusion of the H atom from the N–H bond. Some careless circling overlapped the boxes, thus nullifying the mark.

(ii) Most candidates knew that a dicarboxylic acid and a diamine should be drawn, but many candidates did not follow the instructions to show all of the atoms and all of the bonds in the functional groups. Weaker performing candidates found this very challenging and often merely redrew sections of the molecule shown in Fig. 6.1, complete with amide linkages.

(iii)(iv)(v)
Better performing candidates recalled these three answers with little difficulty.

(vi) Candidates were not familiar with section 11.8.12 of the syllabus, which gives the general structure of amino acids as:

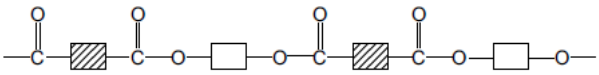


Thus, an amino acid with three carbon atoms would need R to be a CH_3 group.

Nearly all candidates did not place the NH_2 group and COOH group on the **same** carbon atom.

(b) (i) Most candidates opted to give 'carboxylic acid' and 'alcohol' for their answers as these would make a single ester. Better performing candidates realised that a polyester needs monomers with two functional groups and were able to give the correct answers of 'dicarboxylic acid' and 'diol' as stated in section 11.8.8(b) of the syllabus.

(ii) The structure of part of PET is shown in section 11.8.10(b) of the syllabus.



Candidates are not required to know the formulae of what the boxes represent. Despite this, it was clear that many candidates had been taught these formulae, but most were unable to write the correct formulae instead of drawing simple boxes.

CHEMISTRY

Paper 0620/43
Theory (Extended)

Key messages

- Candidates find questions challenging that ask them to state the observations or to say what they would see when an experiment is performed. Points that should be essential parts of the answers to such questions are:
    - colours and changes in colour
    - effervescence
    - solids dissolving or disappearing
    - precipitates forming.
- It is unnecessary to include names of substances when asked for observations. It is also unnecessary to include tests for gases unless the question asks for them.
- Experimental Chemistry is an extremely important part of Chemistry. The methods/observations/results of experiments are essential in the understanding of theoretical Chemistry.

General comments

Candidates should be advised to read a question carefully before attempting an answer as sometimes they do not gain credit because they did not give the answer required by the question. Also, when answering the different parts of the same question, candidates must be encouraged to refer to previous parts as this could prevent confusion and help them avoid giving incorrect responses.

Comments on specific questions

Question 1

(a) This was answered extremely well. Ethane and hydrogen were seen occasionally.

(b) This was answered well**.** Hydrogen was a fairly common answer.

(c) The majority of candidates answered this correctly. This was the least challenging part of **Question 1**.

(d) This was answered reasonably well. Bauxite was a common error. Sodium chloride was seen occasionally.

(e) This was answered very well. Bauxite and cryolite were the most common errors.

(f) This was the most challenging part of **Question 1**. Many gave ethane, ethene or ethanol as the answer.

(g) This was answered quite well. Graphite was a very common incorrect answer.

(h) This was answered quite well. Silicon(IV) oxide and cryolite were common errors.

(i) This was answered very well. There were no common errors.

Question 2

(a) Many candidates successfully repeated the syllabus definition of electrolysis.

(b) (i) Iodide was often seen instead of iodine**.** Copper(II) was commonly seen instead of copper.

(ii) Candidates found this question very challenging. O^{2-} was very commonly seen as the only species on the left-hand side. Those who realised that OH^- was the ion that was discharged usually got the equation completely correct.

(c) (i) Candidates found this amongst the most challenging questions on the whole paper. There was confusion with the extraction of aluminium in some cases. This led to reference to the anode reacting with oxygen in the air. In such cases, it was usually stated that the anode was made of carbon.

(ii) This was answered reasonably well. Copper(II) was commonly seen instead of copper.

(iii) Candidates found this question very challenging. Some candidates described the formation of copper e.g. pink-brown solid. 'Becoming colourless' was another common incorrect answer; 'becomes blue' was also seen occasionally.

The correct answer had to make it clear that there is no change to the appearance of the electrolyte.

Question 3

(a) This was answered extremely well. There were no common errors.

(b) (i) This was answered very well. There were no common errors.

(ii) $NaSnO_3$ was seen occasionally as the formula of the sodium salt. Many formulae such as NaSn did not use the SnO_3^{2-} ion.

(c) This question was answered reasonably well.

(d) (i) This was answered extremely well. Both dots and crosses were almost always used correctly. Non-bonding electrons on some or all of the chlorine atoms were occasionally missing. Good practice was largely followed in drawing the non-bonding electrons in pairs.

(ii) There were some excellent answers to this question.

Common errors included the following phrases:

- weak covalent bonds
- covalent bonds are weaker than ionic bonds
- SnO has ionic bonds with intermolecular forces
- structures are weak (it must be bonds)
- forces of attraction between bonds (it must be between molecules or ions).

Candidates should be aware that intermolecular forces only exist between simple molecules.

Very few candidates referred to a giant ionic structure in tin(II) oxide.

(e) (i) This was found to be very challenging. Candidates often omitted to mention the fact that the layer of aluminium oxide was unreactive. The unreactivity of aluminium was often quoted in error.

(ii) The ionic equation for experiment 2 was often given as:
$Mg^{2+} + SO_4^{2-} \rightarrow MgSO_4$

It was also common to see Mg^{2+} as a reactant in experiment 2.

Ionic half-equations were seen occasionally. Spectator ions were seen in cases when ionic equations were attempted. However, attempts at purely ionic equations were very rare.

(f) (i) Very few candidates referred to the substance being chemically combined with water. The most common answers only mentioned containing water.

(ii) 2SnO and $4NO_2$ were usually correct. $40H_2O$ was seen only rarely.

Question 4

(a) (i) This was answered quite well. Some candidates reversed the correct colours i.e. gave colourless to blue instead of blue to colourless.

(ii) Many commented that universal indicator is only used to determine pH. The fact that universal indicator has several colours was often omitted.

(b) Candidates found the mole calculation much less challenging than in previous years.

(c) Several candidates described how to prepare an aqueous solution of sodium sulfate, which was unnecessary. Some candidates chose to heat to constant mass. Filtration at the start is unnecessary because there is no reason to filter a solution. The main omissions were that there was no indication of when to stop heating and there was no method of drying described.

(d) This was answered well. $KHSO_4$ was occasionally seen as a reactant. The equation for complete neutralisation with K_2SO_4 as a product was seen very occasionally. The formula of potassium hydroxide was sometimes seen as KHO. The formula of sulfuric acid was occasionally incorrect.

(e) (i) This was answered well. There were no common errors.

(ii) Lilac (flame) was most commonly seen. Bubbles were mentioned occasionally. Candidates found the rest of the question very challenging. Most of the answers ignored the requirement to 'state the observations'.

(f) (i) Candidates found this question very challenging. The candidates who calculated the number of moles of zinc as 0.005 then usually went on to say the number of moles of zinc is less than the number of moles of sulfuric acid. It was necessary to make a comment about the mole ratio in the equation of 1 : 1 or to say 0.005 moles of acid is required to react with all the zinc or 0.01 moles of zinc is required to react with all the acid. Such statements were usually omitted.

(ii) Candidates found this much more challenging than the other calculations on the paper. The correct answer was occasionally rounded to 2 significant figures. All the values in the question are to 3 significant figures which is a good indication that 3 significant figures are required in the answer. Many candidates multiplied the Avogadro constant by 48.0. Others divided 48.0 by 24 instead of 24 000 to calculate the number of moles.

Question 5

(a) (i) This was answered reasonably well. Many candidates realised that it was insufficient to say that oxygen was produced and went further to say that the oxygen escaped from the apparatus. Oxygen will 'run to the air' or 'fly away' were occasionally given as answers. Candidates should be aware that matter being lost from the apparatus is the only possible cause for a decrease in mass.

(ii) It was essential to refer to hydrogen peroxide to gain credit. A few candidates referred to the catalyst being used up. Others referred to reactants without specifying hydrogen peroxide.

(iii) The essential part of a correct answer was to mention that the exact time could not be determined because the time intervals were large. Many candidates misunderstood the question and suggested errors that could have been made during the experiment or even that the reaction had not reached completion. Human error was mentioned occasionally. Others referred to the decrease in mass being too small and therefore difficult to measure.

(b) (i) Many candidates mentioned that particles had more energy but sometimes omitted to refer to the energy as kinetic energy. Increase in collision frequency was well known.

Not all candidates referred to the activation energy. Those that did often omitted to mention that more particles or more of the collisions had energy greater than or equal to the activation energy.

(ii) It is essential for candidates to clearly show that the line started exactly at the same place as the original line. The line also had to level off at the same mass as the original and before the original. In many cases it was difficult to tell whether these criteria had been met.

(c) (i) The key part to a correct answer was reference to oxidation number. If candidates mentioned oxidation number, it was only rarely stated to be the oxidation number of manganese. Oxidation number of 4 rather than +4 was commonly seen as an answer. Many candidates referred to valency (not a syllabus term) or charge on the ion instead of oxidation number. Others referred to electrons being transferred or shared. Some candidates thought that the Roman numeral (IV) referred to 5, 6 or 7.

(ii) This was answered quite well. Some referred to the catalyst being used up and therefore a loss of mass.

(d) (i) This was answered well. Some candidates stated that concentrations would not be constant.

(ii) This was answered quite well. References to exothermic reaction should make it clear that this referred to the forward reaction. Many candidates referred incorrectly to the exothermic side or the endothermic side as opposed to the exothermic reaction or endothermic reaction.

(iii) This was answered very well. However, many candidates referred incorrectly to the reaction with fewer molecules or the reaction with more molecules as opposed to the side with fewer molecules or the side with more molecules. Particles were occasionally referred to instead of molecules.

Question 6

(a) Hydrocarbons must be referred to as compounds or molecules. It is essential to mention that hydrocarbons contain hydrogen and carbon only.

(b) (i) The most common incorrect answer was $C_{12}H_{24}$.

(ii) Polymerisation was the most common incorrect answer.

(c) (i) Those who referred to double bonds often omitted to mention that the double bonds were between carbon atoms. A few candidates considered unsaturated as meaning the opposite of saturated, as in saturated solution.

(ii) Products of substitution containing less than six hydrogen atoms and/or only one bromine atom were seen very often. The most common incorrect answer was C_3H_5Br.

(d) (i) This was answered well. C_2H_2 and C_4H_4 were the most common incorrect answers.

(ii) Additional and condensation were seen occasionally.

(iii) Brackets and/or n should be omitted when a definite number of repeat units are requested. Some candidates drew part of the polymer, which contained more than one repeat unit. A double bond between two carbon atoms was seen occasionally.

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Paper 0620/52
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.

- 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. A line of best fit can be curved or straight, whichever is the best fit for the data points. Straight lines should be drawn with the aid of a ruler and not drawn freehand, curves should be smooth and not just a line which moves from point to point. Graph scales should be chosen such that the plotted data takes up over half of the available space and it is recommended that each major grid line should be equivalent to 1, 2, or 5 (or those numbers multiplied by 10^n) – this is indicated in the Presentation of Data section of the syllabus in the section entitled 'Graphs' (and also recommended by the Association for Science Education (A.S.E.)).

- 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 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.

General comments

The vast majority of candidates successfully attempted all of the questions, and the full range of marks was seen. The vast majority of candidates were able to complete all questions in the time available. The question paper discriminated successfully between candidates of different abilities but was accessible to all. The questions were 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 the solutions used. The confidential instructions stated that both solutions should be made up freshly and not stored and that the distilled water used to make up the aqueous sodium thiosulfate should be boiled and allowed to cool - this was to remove dissolved carbon dioxide.

In answering the planning question (**Question 3**) 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; 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. Most candidates obtained results that showed an increase in time as the volume of aqueous sodium thiosulfate decreased. A small number of candidates did not follow the instruction to record the time in seconds to the nearest whole number.

(b) Many candidates chose an appropriate scale for the *y*-axis. The scale should have been chosen so that the plotted data took up over half of the available length of the *y*-axis. The scale on the *y*-axis did not need to start at zero. The best graphs had the scale on the *y*-axis starting at just below the shortest time recorded in Table 1.1. Candidates who chose difficult scales (such as each 2 cm square being 15 seconds) often made more errors in plotting than candidates who used each 2 cm square as 10 or 20 seconds. The graph line should have been a smooth curve; best-fit lines should not just move from point to point unless the points lie perfectly on a smooth curve.

(c) Better performing candidates were able to correctly state that the contents of the beaker were stirred to evenly distribute the solutions. It was sufficient to just state that the contents were stirred to mix them. Most answers that did not gain credit stated that the contents were stirred to make the reaction faster or to dissolve the substances.

(d) Almost all candidates were able to identify the experiment with the shortest time as having the highest rate of reaction.

(e) Many candidates gained full credit. Marks were awarded for:

- Working shown on the graph at 12.5 cm^3. Ideally, this should be a line up from 12.5 cm^3 on the *x*-axis to the line and across to the *y*-axis. It was not uncommon for candidates to use 12, 12.05 or 13 rather than 12.5.
- A correct reading from the *y*-axis. Candidates who had chosen a more difficult scale were more likely to make an error on the reading compared to those who had each big grid square as 10 or 20.
- Giving correct units for their value. This should have been ‘s’ but ‘seconds’, ‘sec’ or ‘secs’ were accepted.

(f) (i) The fact that a burette is more accurate than a measuring cylinder was well known.

(ii) It is evident that some candidates were not aware of the difference between a dropping (Pasteur) pipette and a volumetric pipette. A very common incorrect answer was to say that pipettes only add small volumes or drops. The required answer was that volumetric pipette only measure a fixed volume, and the volumes of aqueous sodium thiosulfate were not fixed or did not match the sizes of volumetric pipettes available. A few candidates also correctly stated that addition from a volumetric pipette is slow and so the reaction would have started before all of the aqueous sodium thiosulfate was added.

(iii) If an investigation is giving reliable results, then each time the experiment is done the results obtained will be the same or similar. To check the results are reliable the experiment needs to be repeated, and the results compared to see if they are similar. Repeating and finding the mean improves accuracy (as random errors are removed) but does not check reliability. Many candidates did not gain credit because they ‘repeated and found the mean’ but did not compare.

(g) This was a demanding question. The best answers explained that as a greater depth of liquid would be looked through, it would make it harder to see the text and so times for the text to become visible would increase. A very common error was to say that the ‘rate of reaction would not change, as the solutions had the same volume, concentration or temperature’.

(h) Most candidates realised that the key to this question was the temperature. To determine whether the reaction is exothermic or endothermic, the change in temperature from the start to the end needs to be found. Candidates who just stated ‘measure the temperature’ did not gain credit as just measuring the temperature once will not tell you if it has increased or decreased. A common error was to name the apparatus required rather than state the measurements.

Question 2

(a) The vast majority of candidates gave a flame-test colour that agreed with the supervisor and was either yellow or orange.

(b) The majority of candidates noted a green precipitate forming and that the precipitate remained when excess aqueous sodium hydroxide was added. A few candidates incorrectly stated the precipitate was blue-green or grey-green. A significant minority of candidates stated that the precipitate dissolved in excess; this is not possible. These candidates may not have mixed the contents of the boiling tube as the aqueous sodium hydroxide was added and so obtained a clear layer at the top of the boiling tube.

(c) Most candidates correctly noted the formation of bubbles on the magnesium.

(d) Most candidates correctly noted the formation of a brown solution or precipitate and bubbles. As the question did not state that candidates should test any gas produced, there was no need for candidates to test the gas formed.

(e) Many candidates noted the formation of a cream precipitate. It can be difficult to differentiate between the colours of silver halide precipitates, but it should be something candidates are familiar with. Leaving the reaction mixture to stand can help as the precipitate settles to the bottom.

(f) Many candidates correctly identified the three ions present in solid **M**. It should be noted that a flame test colour of yellow or orange is accepted for sodium ions. It was evident that some candidates thought that an orange flame test indicated calcium ions. However, the flame test colour in the 'Notes for use in qualitative analysis' states that calcium produces an orange-red flame and not an orange flame.

(g) The mark allocation of two indicates to candidates that two observations were required. Candidates were asked to test any gas produced, and so credit was available for describing and reporting the result of a positive gas test they carried out. The expected observations were 'effervescence' and that, when tested, 'the gas produced turned limewater milky'. While many correct observations were seen, some observations were impossible given the reagents used.

(h) Candidates were asked to test any gas given off, and so credit was available for describing and reporting the result of a positive gas test that they carried out. The only gas that could have been made in this reaction is ammonia, yet a variety of positive gas tests were seen, with carbon dioxide being the most common incorrect positive test.

(i) Many candidates were able to correctly identify solid **N**. However, a common error was to identify the gases formed in **(g)** and **(h)** rather than to identify the solid.

Question 3

Candidates who realised that the best way to determine which of two solutions contains the greater concentration of acid is to carry out a titration, often performed well on this planning task. Some excellent and succinct descriptions were seen. As this was a quantitative task, there was a requirement to control volumes of reagents.

The expected steps in the titration were:

- add a specified volume of one reagent to a suitable reaction vessel, such as a conical flask
- add a named acid-alkali indicator, such as methyl orange, to the conical flask
- add the other reagent gradually to the contents of the conical flask using a burette
- swirl the flask while adding the reagent from the burette
- stop adding the reagent from the burette when the colour changes
- describe how the results will show which juice contains the more concentrated citric acid.

The more common errors were to not specify a volume of the reagent in the flask, not to name an appropriate indicator and not to mix the contents of the flask during the titration. It should be noted that universal indicator is not appropriate to use in a titration. A common error was to use DCPIP as the indicator.

DCPIP is not used as an acid-base indicator; it is a redox dye and can be used to assess the amount of vitamin C (ascorbic acid, not citric acid) in a sample – the vitamin C reduces blue DCPIP to a colourless compound.

The most common alternative method seen to a titration was to base the investigation on rate of reaction. In these cases, candidates added a known volume of aqueous sodium hydroxide to a known volume of juice and timed something. The problem with this method is that there is no visible change in the reaction, no gas is made and so no gas can be collected nor fizzing observed. Adding an acid-alkali indicator and timing a colour change will not work as the reaction when an acid reacts with an alkali is oppositely charged ions combining ($H^+ + OH^- \rightarrow H_2O$) – this reaction is almost instantaneous.

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Paper 0620/53
Practical Test

Key messages

- In the qualitative analysis question (**Question 2**), 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 observations, then stating that a gas is given off is not an observation. The relevant observation would be effervescence or fizzing or bubbles (of a gas). Similarly, when asked for observations when a gas is evolved, then identifying the gas is not an observation. The test and the result of the test are needed.

- Not all of 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.

- 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.

- 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. A line of best fit can be curved or straight, whichever is the best fit for the data points. Straight lines should be drawn with the aid of a ruler and not drawn freehand; curves should be smooth and not just a line which moves from point to point. Graph scales should be chosen such that the plotted data takes up over half of the available space and it is recommended that each major grid line should be equivalent to 1, 2, or 5 (or those numbers multiplied by 10^n) – this is indicated in the Presentation of Data section of the syllabus in the section entitled 'Graphs' (and also recommended by the Association for Science Education (A.S.E.)).

- Readings recorded from a given item of apparatus should all be recorded to the same resolution (the same number of decimal places).

General comments

The vast majority of candidates successfully attempted all of the questions, and the full range of marks was seen. Most candidates were able to complete the questions in the time available. The question paper discriminated successfully between candidates of different abilities but was accessible to all and 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, 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 credit will not be awarded just for a name in a list of other apparatus.

There was a lot of positive evidence to suggest that more practical work was being used in the teaching of this syllabus than has been seen in the last few years.

Comments on specific questions

Question 1

(a) The majority of candidates successfully completed the table with all fourteen temperature readings and all temperature decreases correctly calculated. The recording of temperatures to the nearest 1 decimal place was generally done well, with only a small proportion recording 8.0 as 8 for example. Most candidates got results similar to those expected, although some worked out difference from previous temperature rather than rather than from the beginning of the experiment despite the equation being provided.

(b) Most of the graphs had a suitable scale on the *y*-axis, usually 2 cm grid square = 2 °C. Some candidates selected difficult scales where each 2 cm grid square was 1.5 or 3 °C; these candidates often made errors in plotting. Each large grid square should be 1, 2 or 5×10^n.

The points were also generally correctly plotted. There are still many candidates who think that lines of best fit must be straight lines. Some candidates forgot to label their lines.

(c) There was confusion here with explanations in terms of heat energy rather than the simple realisation that the reactions must be endothermic as the temperatures were decreasing.

(d) The comparison of temperature decreases in the two experiments caused some difficulty in explanation by candidates. Candidates should have stated that the maximum temperature decrease was greater for Experiment 2 than Experiment 1 and then stated a quantitative relationship such as the maximum temperature decreased by 1.5 times. Few candidates tried to calculate a ratio between the two maximum temperature decreases. Quoting of specific values was not credited.

(e) Nearly all candidates could work out the relevant temperature decrease from their graph, although a few candidates chose the wrong experiment or the wrong time; the most common error was using 50 seconds rather than 45 seconds.

(f) This calculation was very well attempted, with most candidates getting the correct value and the correct units. A few candidates made errors in the rounding of their final answer. Answers given as fractions are not sufficient.

(g) This was possibly the most challenging question on the paper. The main errors in the experiment were heat loss due to a lack of insulation, the use of a measuring cylinder rather than a burette or volumetric pipette and water remaining in the boiling tube at the end of the first experiment. The use of a thermometer for stirring, not taking readings at eye level and the difference in the initial temperatures are not errors in the experiment.

Question 2

(a) The observations seen suggest that many candidates heated the solid strongly rather than gently. Many candidates noted a colour change but not the fact that condensation formed or that a liquid/solution formed in the boiling tube.

(b) As the question stated that aqueous sodium hydroxide should be added dropwise and then in excess, candidates should give an observation for each step. A white precipitate forms on dropwise addition which should dissolve in excess. Some candidates gave answers which suggested they did not mix the contents of the boiling tube when adding in excess and so reported a white precipitate at the bottom and a colourless solution above.

(c) Similarly, as the question stated that aqueous ammonia should be added dropwise and then in excess, candidates should give an observation for each step. A white precipitate forms on dropwise addition which should remain in excess. Some candidates gave answers which suggested they did not mix the contents of the boiling tube when adding in excess and so reported a white precipitate at the bottom and a colourless solution above; this colourless solution would be aqueous ammonia that has not mixed with the precipitate.

(d) Many candidates reported the expected cream precipitate. It was not uncommon for candidates to report a white precipitate. Candidates should be familiar with the colours of silver halide precipitates; comparing the precipitate colour to a sheet of white paper can help determine if the precipitate is white or cream. Some candidates reported that there was no change; the most probable reason for this is the adding of incorrect reagents when they performed the test.

(e) Many candidates correctly identified the aluminium and bromide ions. It should be noted that the term 'bromine ion' is not accepted for 'bromide ion'.

(f) Most candidates correctly reported a yellow flame. Orange is accepted as an alternative to yellow, but red-orange is not accepted as that is the flame test colour for a different cation.

(g) Most candidates correctly reported that there was no change, although some candidates reported impossible changes such as the formation of precipitates.

(h) Most candidates noted the change from purple to colourless. 'Clear' is not the same as colourless. Colourless means having no colour, while clear means being able to see through something, but it can be any colour.

(i) While many candidates correctly identified sodium ions in solid **S**, calcium ions was a common incorrect answer. Yellow or orange was accepted as the colour for sodium ions in a flame test, calcium ions was not be accepted as a conclusion from an orange flame test. The 'notes for use in qualitative analysis' state that the flame test colour for calcium ions is orange-red (for which brick red would be accepted).

Question 3

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

This was a task involving the separation of calcium carbonate from a mixture and then the calculation of the percentage of calcium carbonate in the mixture.

The vast majority of candidates used a method based on the information in the question.

The expected steps in the plan were:
- a stated mass of the mixture
- addition of distilled water to the mixture, with stirring, to dissolve the calcium chloride
- filtration, leaving a residue of calcium carbonate and aluminium oxide
- addition of aqueous sodium hydroxide to the mixture, with stirring, to dissolve the aluminium oxide
- filtration followed by washing and drying to get a pure sample of calcium carbonate
- weighing to get the mass of calcium carbonate
- calculating the percentage of calcium carbonate in the original mixture.

Many excellent and succinct answers were seen. However, a common reason for candidates not obtaining full credit was the omission of details. For example, some candidates did not specify stirring to aid dissolving or washing and drying the residue.

A few candidates omitted the treatment with distilled water, which meant that calcium chloride was left to form a precipitate with the aqueous sodium hydroxide. A smaller number used the aqueous sodium hydroxide before adding water, which had a similar effect.

A few candidates did not start with the mixture but were clearly carrying out the tests on the three individual compounds, which gained no credit. A significant minority confused the terms filtrate and residue.

There were other acceptable approaches, such as the use of an acid to react with the calcium carbonate, followed by collection of the carbon dioxide. However, these methods were rarely seen.

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 unnecessary.

CHEMISTRY

Paper 0620/61
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. A line of best fit can be curved or straight, whichever is the best fit for the data points. Straight lines should be drawn with the aid of a ruler and not drawn freehand; curves should be smooth and not just a line which moves from point to point. Graph scales should be chosen such that the plotted data takes up over half of the available space and it is recommended that each major grid line should be equivalent to 1, 2 or 5 (or those numbers multiplied by 10^n) – this is indicated in the Presentation of Data section of the syllabus in the section entitled 'Graphs' (and also recommended by the Association for Science Education (A.S.E.)).

- 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 produced 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, fizzing or bubbles (of a gas).

- When a question asks for the name of a chemical, a correct formula is normally acceptable. However, if a candidate answers with an incorrect formula, then credit will not be awarded. When a question asks candidates to identify ions or a substance then candidates may answer using names or formulae.

- In qualitative analysis, not all of 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 vast majority of candidates successfully attempted all of the questions, and the full range of marks was seen. The vast majority of candidates were able to complete all questions in the time available. The question paper discriminated successfully between candidates of different abilities but was accessible to all. The questions were 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, nor the aims of the experiment, nor a list of safety precautions or a list of dependent and independent variables. Where there is credit is 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 majority of the candidates realised that the sodium sulfate is being dissolved in **step 1**.

(b) The vast majority of candidates identified that water was being removed in **step 3**.

(c) Some of the candidates were confused between **step 3** and **step 4** and stated that the residue should be left to dry in a warm place to gain a larger yield, rather than realising that the filtrate needed to be left to cool to allow crystals to form before they are left to dry.

(d) (i) Most candidates stated that water was used to rinse the residue (to remove sodium sulfate).

(ii) While the majority of candidates realised that the water was used to remove sodium sulfate, some candidates thought that the water was being removed by the process of washing.

Question 2

(a) The majority of candidates performed well here. The most common errors were either not recording the volume of aqueous barium nitrate or the level of precipitate to the same resolution (number of decimal places). The most common error was in Experiment 3, stating the height of the precipitate as 3 and not 3.0.

(b) The ideal scale to use was one where each big grid square was equivalent to 1 cm. Candidates who used this scale were normally able to plot all points correctly. The question asked for two lines of best fit, and most candidates joined the first five experiments with a straight line, using a ruler, and the second best-fit line, using a ruler, for the last three experiments. A few candidates did not extend the lines so they crossed, but directly joined the points for Experiments 5 and 6 together with a straight line.

(c) Many candidates gained full credit. Marks were awarded for:

- Working shown on the graph at 2.8 cm^3. Ideally this should be a line up from 2.8 cm^3 on the *x*-axis to the line and across to the *y*-axis.
- A correct reading from the *y*-axis. Candidates who had chosen a more difficult scale were more likely to make an error on the reading compared to those who had each big grid square as 1 cm.

(d) 4.6 cm was the most common prediction for the precipitate height, but fewer candidates realised that this was because all the magnesium sulfate had reacted and was a limiting reagent. The most common reason given was that the height of the precipitate had remained constant for the last three experiments.

(e) Many candidates found this question challenging and only the better performing candidates gained full credit. Most candidates realised that the precipitate height would be less using aqueous barium nitrate of half the concentration and sketched a line with a positive gradient below the original plotted line. Only a small number of candidates realised that the final height of the precipitate should be 3.6 cm at a volume of 6 cm^3 of barium nitrate.

(f) The better performing candidates were able to correctly state that the measuring cylinder was inverted several times to evenly distribute the solutions. It was sufficient to just state the measuring cylinders were inverted to mix them. Most answers that did not gain credit stated that the measuring cylinder was inverted to make the reaction faster, to dissolve the substances or to start the reaction.

(g) The better performing candidates realised that the measuring cylinder was left to stand, so that the precipitate settles at the bottom of the measuring cylinder and so the height can be measured more accurately. Most answers that did not gain credit for stating that the measuring cylinder was left to stand so the precipitate had time to fully form or so that there was time for all the substances to react or to allow for the maximum amount of precipitate to form. A few weaker responses stated it was so the precipitate was evenly distributed in the measuring cylinder.

(h) (i) The fact that a burette is more accurate than a measuring cylinder was well known. Many candidates stated that a burette is more precise than a measuring cylinder. Answers based on measuring cylinders having a greater parallax error or being easier to spill were not credited since these are due to the user of the apparatus and not the apparatus itself.

(ii) Some excellent answers were seen with some candidates explaining that volumetric pipettes can only be used to measure a fixed volume so they could not be used to measure the varying volumes required. Some candidates clearly did not realise the difference between a volumetric pipette and a dropping (Pasteur) pipette and stated that pipettes can only add drops or cannot measure volumes greater than 5 cm^3. There was also some confusion with a question on a previous question paper in which the reaction occurring as the reactant was added slowly from a pipette was the problem. In this experiment, the volumes of aqueous solutions are being added to form a precipitate, and the experiment is not based on the rate of the reaction; therefore, the addition being slow is not an issue. Many candidates simply stated that pipettes were more accurate than burettes.

Question 3

(a) The majority of candidates were able to state that a red flame colour was produced by lithium sulfite.

(b) Nearly everyone correctly wrote that the acidified aqueous potassium manganate(VII) would change from purple to colourless. It should be noted that clear is not the same as colourless. Colourless means having no colour, while clear means being able to see through something, but it can be any colour.

(c) (i) Similarly, most candidates could identify sulfur dioxide as the gas produced in the sulfite test.

(ii) Candidates generally found this question difficult, and despite gaining credit for the sulfite test in **(c)(i)**, went on to give a positive test for sulfate ions with barium nitrate. Almost all candidates stated the observation would be a white precipitate.

(d) Most candidates correctly identified chromium(III) as one of the ions in solid **U**. A few candidates stated the other ion in solid **U** was iron without specifying iron(II) or iron(III) and this did not get credit.

(e) Most candidates performed well on this question with the majority using aqueous sodium hydroxide to distinguish between chromium(III) and iron(II). A common phrase was to state 'put on a near surface on standing' and iron(II) turns brown. 'Leave to stand' would be a much clearer statement.

(f) Many candidates correctly identified the anion as iodide ions. It should be noted that the term 'iodine ion' is not accepted for 'iodide ion'.

Question 4

Most candidates were able to perform well on this planning task, as it was based on chromatography, which is a familiar process for most candidates. Very few candidates tried a non-chromatography based approach.

The most common error was one of omission, with candidates assuming that they already had a sample of the coloured compounds, while the question stated they had to state how they would extract the coloured compounds from the beetroot. This resulted in candidates not being able to gain credit for extracting the dye from the beetroots – the expected method for this was to crush the beetroot with water using a pestle and mortar.

There were many good and clear descriptions of the chromatography process, although a common error was using a solvent up to the depth of the spot of dye rather than ensuring the solvent level was below the dye or the base-line. The aim of the experiment was to find how many different coloured compounds were contained in the beetroot, comments on using a locating agent for invisible colours were ignored (as if the compounds are coloured, they cannot be invisible). The simplest way of finding how many coloured compounds are in the beetroot is to count the number of spots obtained as a result of chromatography. Calculation of the R_f value of **each** spot to identify the compounds was also credited (as if you know what the compounds are then you know how many there are).

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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. A line of best fit can be curved or straight, whichever is the best fit for the data points. Straight lines should be drawn with the aid of a ruler and not drawn freehand, curves should be smooth and not just a line which moves from point to point. Graph scales should be chosen such that the plotted data takes up over half of the available space and it is recommended that each major grid line should be equivalent to 1, 2, or 5 (or those numbers multiplied by 10^n) – this is indicated in the Presentation of Data section of the syllabus in the section entitled 'Graphs' (and also recommended by the Association for Science Education (A.S.E.)).

- 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 produced 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 normally acceptable. However, if a candidate answers with an incorrect formula, then credit will not be awarded. When a question asks candidates to identify ions or a substance then candidates may answer using names of formulae.

- In qualitative analysis, not all of 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 vast majority of candidates successfully attempted all of the questions, and the full range of marks was seen. The vast majority of candidates were able to complete all questions in the time available. The question paper discriminated successfully between candidates of different abilities but was accessible to all. The questions were generally well-answered, with very few blank spaces.

Some candidates omitted questions when the answer needs to be written on a diagram and there is no dotted answer line. These errors of omission would not occur if candidates read the whole of the questions on the examination paper rather than just looking for dotted lines on which answers should be written.

In 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 or a list of dependent and independent variables. 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 majority of the candidates realised that the mercury(II) bromide in the left hand boiling tube should be heated. A small minority of candidates drew an arrow to show the ice in the beaker being heated. It was not uncommon for candidates to not attempt this question part, presumably because they had not seen it, as it required something to be added to the diagram rather than on a dotted answer line.

(b) The vast majority of candidates identified the apparatus as a boiling tube or test-tube. Vague answers, such as 'tube' alone did not gain credit.

(c) The majority of candidates were able to identify the process as electrolysis.

(d) There were three acceptable reasons why platinum is a suitable material for the electrodes:

- It is a good conductor of electricity. 'Good conductor' alone was insufficient as platinum, in common with all metals, is also a good conductor of heat.
- It melts above the boiling point of the electrolyte. A statement of it having a high melting point was also sufficient.
- It is inert or unreactive. Statements that platinum did not react with a substance in the boiling tubes, such as mercury(II) bromide or bromine, were sufficient. Statements saying platinum did not react with water or did not rust did not gain credit as there was no water in the boiling tube and so that property is irrelevant.

A significant number of candidates gave the same reason twice, normally by stating that the platinum will not react as one reason and then stating it is inert as the other reason. These are two equivalent statements and so can only be credited once.

(e) Candidates who used the data in Table 1.1 or who were aware that mercury had a high density correctly showed that the mercury would collect at the bottom of the left-hand boiling tube. A common error was to show the mercury in the test-tube in the ice-bath, presumably because they thought the mercury would have boiled off.

(f) This question asked for an explanation. Simple statements saying that the ice cooled something were insufficient as it did not say why it needed to be cooled. The idea of the condensation of a gaseous product to a liquid product was required. Answers in terms of the condensation of steam to form water were rejected as there is no water anywhere in this reaction. Many candidates gave full answers, stating that the ice cooled the bromine gas so that it formed liquid bromine.

Question 2

(a) The majority of candidates performed well. The most common errors were either not recording the volumes of sodium thiosulfate to the same resolution (number of decimal places) or recording the time to one decimal place. The practical instructions stated 'record the time in seconds to the nearest whole number'. A small minority of candidates left the times in minutes and seconds or completely ignored the minute hand and so gave answer showing just the seconds and ignoring the minutes.

(b) The ideal scale to use was one where each big grid square was equivalent to 20 seconds. Candidates who used this scale were normally able to plot all five points correctly. A significant number of candidates opted for more awkward scales, such as each big grid square being equivalent to 30 seconds. While this scale was acceptable, it often resulted in errors in plotting the data from Table 2.1. A best-fit curve was asked for; better performing candidates treated the point at (7, 63) as an anomaly and drew excellent smooth curves which ignored this point. It was very common for candidates to not treat any of the points as anomalous and draw a curve which meandered over the grid, taking in all five points; these candidates did not receive credit for drawing the best-fit line.

(c) The best answers correctly stated that the contents of the beaker were stirred to evenly distribute the solutions. It was sufficient to just state that the contents were stirred to mix them. Most answers that did not gain credit stated that the contents were stirred to make the reaction faster or to dissolve the substances.

(d) Almost all candidates were able to identify Experiment 1 as having the highest rate of reaction. A small minority of candidates opted for Experiment 5, which had the longest time.

(e) Many candidates gained full credit. Marks were awarded for:

- Working shown on the graph at 12.5 cm^3. Ideally, this should be a line up from 12.5 cm^3 on the *x*-axis to the line and across to the *y*-axis. It was not uncommon for candidates to use 12, 12.05 or 13 rather than 12.5.
- A correct reading from the *y*-axis. Candidates who had chosen a more difficult scale were more likely to make an error on the reading compared to those who had each big grid square as 20 seconds.
- Giving correct units for their value. This should have been 's' but 'seconds', 'sec' or 'secs' were accepted.

(f) (i) The fact that a burette is more accurate than a measuring cylinder was well known.

(ii) It is evident that some candidates were not aware of the difference between a dropping (Pasteur) pipette and a volumetric pipette. A very common incorrect answer was to say that pipettes only add small volumes or drops. The required answer was that volumetric pipettes only measure a fixed volume, and the volumes of aqueous sodium thiosulfate were not fixed or did not match the sizes of volumetric pipettes available. A few candidates also correctly stated that addition from a volumetric pipette is slow and so the reaction would have started before all of the aqueous sodium thiosulfate was added.

(iii) If an investigation is giving reliable results, then each time the experiment is done the results obtained will be the same or similar. To check the results are reliable, the experiment needs to be repeated, and the results compared to see if they are similar. Repeating and finding the mean improves accuracy (as random errors are removed) but does not check reliability. Many candidates did not gain credit because they 'repeated and found the mean' but did not compare.

(g) This was a demanding question. The best answers explained that as a greater depth of liquid would be looked through, it would make it harder to see the text and so the times for the text to become visible would increase. A very common error was to say that the 'rate of reaction would not change, as the solutions had the same volume, concentration or temperature'.

(h) Most candidates realised that the key to this question was the temperature. To determine whether the reaction is exothermic or endothermic, the change in temperature from the start to the end needs to be found. Candidates who just stated 'measure the temperature' did not gain credit as just measuring the temperature once will not tell you if it has increased or decreased. A common error was to name the apparatus required rather than state the measurements.

Question 3

(a) Many candidates were able to state that a yellow flame is not hot enough or that the yellow colour will mask or prevent them seeing the flame test colour and so gained credit. Candidates who just stated 'a roaring flame should be used' did not gain credit as they had not said why the yellow (safety) flame is not suitable.

(b) Many fully correct answers were seen. The two most common errors were:

- to give chromium(III) as one of the ions. While chromium(III) ions do give a green precipitate when reacted with aqueous sodium hydroxide, the precipitate will dissolve in excess sodium hydroxide. In **test 3** in Table 3.1, the precipitate did not dissolve in excess.
- to give nitrate as one of the ions. While **test 4** in Table 3.1 is the test for nitrate ions, the result was negative and so shows there are no nitrate ions in solid **M**.

(c) The mark allocation of two indicates to candidates that two observations were required. The question states 'any gas produced is tested', so answers should have recorded the details for the gas test that gives a positive result. Many candidates correctly stated that there would be effervescence and that the gas would turn limewater milky.

(d) The test described is the test for ammonium ions and so ammonia gas should have been produced. As the question states 'any gas produced is tested' answers should have recorded the details for the gas test that gives a positive result, which in this case is that damp red litmus turns blue.

(e) The addition of aqueous ammonia is used to identify the presence of some metal ions, as the cation in **N** is ammonium, there should have been no observed change on adding aqueous ammonia.

Question 4

Candidates who realised that the best way to determine which of two solutions contains the greater concentration of acid is to carry out a titration, often performed well on this planning task. Some excellent and succinct descriptions were seen. As this was a quantitative task, there was a requirement to control volumes of reagents.

The expected steps in the titration were:

- add a specified volume of one reagent to a suitable reaction vessel, such as a conical flask
- add a named acid-alkali indicator, such as methyl orange, to the conical flask
- add the other reagent gradually to the contents of the conical flask using a burette
- swirl the flask while adding the reagent from the burette
- stop adding the reagent from the burette when the colour changes
- describe how the results will show which juice contains the more concentrated citric acid.

The more common errors were to not specify a volume of the reagent in the flask, not to name an appropriate indicator and not to mix the contents of the flask during the titration. It should be noted that universal indicator is not appropriate to use in a titration. A common error was to use DCPIP as the indicator. DCPIP is not used as an acid-base indicator; it is a redox dye and can be used to assess the amount of vitamin C (ascorbic acid, not citric acid) in a sample – the vitamin C reduces blue DCPIP to a colourless compound.

The most common alternative method seen to a titration was to base the investigation on rate of reaction. In these cases, candidates added a known volume of aqueous sodium hydroxide to a known volume of juice and timed something. The problem with this method is that there is no visible change in the reaction, no gas is made and so no gas can be collected nor fizzing observed. Adding an acid-alkali indicator and timing a colour change will not work as the reaction when an acid reacts with an alkali is oppositely charged ions combining ($H^+ + OH^- \rightarrow H_2O$) – this reaction is almost instantaneous.

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Key messages

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- 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**), 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 observations, then stating that a gas is given off is not an observation. The relevant observation would be effervescence, fizzing or bubbles (of a gas). Similarly, when asked for observations when a gas has evolved, then identifying the gas is not an observation. The test and the result of the test are needed.

- Not all of 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.

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

General comments

The vast majority of candidates successfully attempted all of the questions, and the full range of marks was seen. Most candidates were able to complete the questions in the time available. The question paper discriminated successfully between candidates of different abilities but was accessible to all and was generally well-answered, with very few blank spaces.

Some candidates tend to omit questions when the answer needs to be written on a diagram and there is no dotted answer line. These errors of omission would not occur if candidates read the whole of the questions on the examination paper rather than just looking for dotted lines on which answers should be written.

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There was a lot of positive evidence to suggest that more practical work was being used in the teaching of this syllabus than has been seen in the last few years.

Comments on specific questions

Question 1

(a) Most candidates correctly identified the beaker, although the delivery tube was less well known.

(b) Few candidates identified the error in the apparatus as the stopper, which meant that pressure would build up in the sealed system. Many answers were based on the lack of support for the vertical test-tube and the risk of it falling. It should be noted that stands and clamps are often not shown on diagrams.

(c) This question proved to be challenging, with about half of the candidates not attempting to draw how the gas should be collected. For those who did attempt it, then a syringe was far easier to draw than collection over water.

(d) Nearly all candidates correctly pointed the heating arrow at the calcium ethanedioate. A few candidates heated the ice.

(e) Most candidates correctly identified the substance collected as water. Calcium carbonate was a common incorrect response.

(f) Most candidates realised that the fume cupboard was needed because carbon monoxide is toxic. This question was well answered.

Question 2

(a) The majority of candidates successfully completed the table with all twelve temperatures read correctly and the temperature decreases correctly calculated. The recording of temperatures to the nearest 0.5 (half a scale division on the thermometer diagrams) was generally done well, with only a small proportion of candidates recording 19.0 as 19 for example. However, a small number of candidates calculated the temperature decreases from the previous value rather than from the beginning of the experiment.

(b) Most of the graphs had a suitable scale on the *y*-axis, usually 20 seconds to each 2 cm square. The points were also generally correctly plotted. Many candidates incorrectly thought that a line of best fit must be a straight line. Some candidates also forgot to label their lines.

(c) There was confusion here with explanations in terms of heat energy rather than the simple realisation that the reactions must be endothermic as the temperatures were decreasing.

(d) The comparison of temperature decreases in the two experiments caused some difficulty in explanation by candidates. The required answer was that ‘the temperature decrease in Experiment 2 was twice as much as in Experiment 1’. The quoting of values was not required or credited.

(e) Nearly all candidates could work out the relevant temperature decrease from their graph, although a few candidates chose the wrong experiment or the wrong time.

(f) This calculation was very well attempted, with most candidates getting the correct value and the correct units. A few candidates made errors in the rounding of their final answer. Answers given as fractions are not sufficient.

(g) This was possibly the most challenging question on the paper. The main errors in the experiment were heat loss due to a lack of insulation, the use of a measuring cylinder rather than a burette or volumetric pipette and water remaining in the boiling tube at the end of the first experiment. The use of a thermometer for stirring, not taking readings at eye level and the difference in the initial temperatures are not errors in the experiment.

Question 3

(a) Water was identified as the colourless liquid by nearly all candidates, who then went on to say that it had come from solid **R**. Better answers realised that it was water of crystallisation or that solid **R** was hydrated.

(b) It was evident that most candidates could use the 'notes for use in qualitative analysis' attached to the question paper as nearly all candidates identified solid **R**.

(c) Similarly, most candidates knew that there would be a yellow flame.

(d) Most candidates could work out that there would be no observation or reaction.

(e) Nearly all candidates correctly wrote that the acidified aqueous potassium manganate(VII) would go from purple to colourless.

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 task involving the separation of calcium carbonate from a mixture and then the calculation of the percentage of calcium carbonate in the mixture.

The vast majority of candidates used a method based on the information in the question.

The expected steps in the plan were:
- a stated mass of the mixture
- addition of distilled water to the mixture, with stirring, to dissolve the calcium chloride
- filtration, leaving a residue of calcium carbonate and aluminium oxide
- addition of aqueous sodium hydroxide to the mixture, with stirring, to dissolve the aluminium oxide
- filtration followed by washing and drying to get a pure sample of calcium carbonate
- weighing to get the mass of calcium carbonate
- calculating the percentage of calcium carbonate in the original mixture.

Many excellent and succinct answers were seen. However, a common reason for candidates not obtaining full credit was the omission of details. For example, some candidates did not specify stirring to aid dissolving or washing and drying the residue.

A few candidates omitted the treatment with distilled water, which meant that calcium chloride was left to form a precipitate with the aqueous sodium hydroxide. A smaller number used the aqueous sodium hydroxide before adding water, which had a similar effect.

A few candidates did not start with the mixture but were clearly carrying out the tests on the three individual compounds, which gained no credit. A significant minority confused the terms filtrate and residue.

There were other acceptable approaches, such as the use of an acid to react with the calcium carbonate, followed by collection of the carbon dioxide. However, these methods were rarely seen.

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 unnecessary.