CHEMISTRY

Paper 0620/11
Multiple Choice (Core)

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

General comments

Candidates found this to be an accessible paper overall. Candidates found Questions **7**, **15**, **27** and **37** to have the least challenge.

Questions **9**, **10**, **11**, **12**, **16**, **32** and **40** were most demanding.

Candidates found it difficult to recall the direction of energy movement in endothermic or exothermic reactions as well as expected observations during reactions.

Comments on specific questions

Question 3

Option **C** was the most commonly chosen, suggesting that candidates recalled the relative charge and location of an electron but not its relative mass.

Question 9

Candidates often find calculations higher demand questions. Only a small number candidates answered this mass-ratio question correctly. Option **C** was chosen by most candidates, which corresponds with the M_r of magnesium chloride rather than its mass.

Question 10

Candidates who performed less well were more likely to choose any of the options. Option **D** was the least likely chosen by all the candidates, suggesting that most candidates could identify at least one of the correct statements about electrolysis.

Question 11

Most candidates recalled that water is the only chemical product of the hydrogen–oxygen fuel cell but assumed that the main form of energy was heat rather than electricity. Option **B** was chosen by many candidates.

Question 12

The direction of energy transfer and temperature changes in an endothermic reaction was challenging for all candidates. The majority of candidates chose option **B**, incorrectly assuming that the reaction mixture would increase in temperature during an endothermic reaction.

Question 16

Most candidates recalled the colour change when water is added to anhydrous copper(II) sulfate. Option **B** was the most commonly chosen incorrect answer where candidates confused the direction of energy transfer.

Question 19

Option **C** was the most commonly chosen option where candidates confused the relative melting points of two different oxides. Candidates should be able to recognise that sodium oxide is ionic and so is solid whereas nitrogen dioxide is a known pollutant gas.

Question 24

Some candidates were unclear what the terms monatomic and diatomic mean and were more likely to choose option **B**, although most candidates recalled the unreactive nature and the electronic configuration of noble gases.

Question 28

Overall, the correct answer was most commonly chosen but all the option were popular, with option **B** most likely to be chosen by candidates who perhaps confused reactant with product.

Question 29

Questions about the make-up of the atmosphere are often well answered but this question proved to be more demanding. Although most candidates recalled the proportions of nitrogen and oxygen, fewer recalled the relative amounts of carbon dioxide and other gases such as argon. Option **B** was the most commonly chosen incorrect answer.

Question 32

The harmful effects of particulates in the air were not well known. Option **B** was chosen by the majority of candidates.

Question 34

Most candidates recognised that hydrocarbons such as ethane readily burn in air so option **B** was not chosen by many candidates. Some candidates confused ethane with ethene and choose option **C**.

Question 35

Relatively few candidates chose options **A** or **D** but many candidates confused the two methods of ethanol formation with option **B** being the most common answer for some candidates.

Question 40

A minority of candidates answered this question correctly. Option **B** was the most popular answer suggesting that candidates identified the sulfate test correctly but perhaps confused the green colour of iron(II) hydroxide precipitate with the green colour of copper salts in a flame test.

CHEMISTRY

Paper 0620/12
Multiple Choice (Core)

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

General comments

The paper discriminated well between candidates although relatively few scored the highest marks.

Questions 1, **9** and **33** had the least demand.

Questions 3, **4**, **8**, **16**, **26**, **27**, **31**, **37** and **39** had the greatest demand.

Questions 3, **5**, **11**, **14**, **19**, **20** and **23** showed the greatest discrimination between candidates.

Questions describing the types of reaction or the type of bonding and the difference between compounds and mixtures were not well answered.

Comments on specific questions

Question 3

The majority of candidates were unclear on the difference between a compound and a mixture. Option **C** was chosen by most candidates. A significant number of candidates chose option **B**, confusing the mixture of an alloy with ionic bonding.

Question 4

Most candidates recognised that the melting and boiling point of a substance can identify whether the substance is pure. Less than half of candidates recognised that chromatography is also used. Option **C** was the most common answer.

Question 8

Candidates did not always recall the general properties of covalent compounds. Many candidates confused the bond type in calcium chloride or confused the direction of electron movement in the formation of an ionic compound. Candidates were almost as likely to choose options **B** or **C** as the correct answer.

Question 13

Some candidates found this question difficult, and the distribution of answers suggests many candidates were guessing. Both the name of the negative electrode and the molten compound were poorly understood or recalled.

Question 14

Although most candidates recalled that the hydrogen–oxygen fuel cell produces electricity, most also thought that carbon dioxide is produced, which suggests some confusion with the combustion of fuels. The most popular response was option **B**.

Question 16

The identification of physical and chemical changes was not well understood with the distribution of answers suggesting many candidates were guessing.

Question 26

The general properties of Group VII elements were not well known. Option **B** was the most popular response with only a minority of candidates choosing either of the two possible displacement reactions.

Question 27

Group VIII elements are known as the noble gases so options **C** and **D** should be ruled out quickly based on the boiling point. However, only a minority of the better performing candidates answered this question correctly and other candidates were more likely to choose any one of the options.

Question 30

Most candidates answered this question correctly and most recognised that the anhydrous salts will change colour whether the water is pure or not. Option **B** was a common incorrect answer suggesting that some candidates were unaware that the pH does not always change when an impurity is present.

Question 31

This question was thought to have a lower demand because candidates can match element symbols to the NPK fertiliser. For this paper, the majority of candidates chose one of the incorrect options, with option **A** being the most commonly chosen.

Question 37

Most candidates recognised the addition polymer, poly(ethene), but its effect or lack of effect with aqueous bromine was not well known. Although relatively few candidates chose option **D**, all the other options were popular.

Question 39

Candidates should recognise the significance of the decimal place to indicate a higher level of precision in the measurement. They should also recognise which pieces of apparatus measure a range of different volumes and which only measure a fixed volume. Options **B** and **D** were the most commonly chosen options.

CHEMISTRY

Paper 0620/13
Multiple Choice (Core)

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

General comments

The average score for this paper was relatively low and few candidates gained the higher marks. For many questions candidates appeared to be guessing.

Candidates found **Questions 33** and **35** to have least demand and **Questions 6**, **7**, **20**, **21**, **22**, **23** and **40** to be more demanding.

Many candidates found fundamental ideas such as the difference between elements and compounds, chemical formula and acids and indicators challenging.

Comments on specific questions

Question 3

This question discriminated well between candidates. Few candidates chose options **A** or **D** but most of the candidates who performed least well chose option **C**, perhaps confusing water as an element.

Question 5

Few candidates chose options **A** or **B**. The majority of candidates who performed least well chose option **C**, confusing the position of the electron with the position of the neutron in an atom.

Question 6

The properties of covalent compounds were not well known by any of the candidates. The correct answer was the least commonly chosen with most candidates across the ability range choosing option **B**. Candidates should recall that simple covalent compounds are poor electrical conductors under all conditions (and that the giant structure of graphite is unusual).

Question 7

Few candidates answered this question correctly. The formation of the ionic bond between Group I and Group VII elements to form ions with noble gas electronic configurations is essential knowledge. Options **B** or **C** were chosen a large majority of the candidates.

Question 11

Most candidates recognised that water taps are electroplated to improve their resistance to corrosion. The thin plating would not improve the strength of the taps. Option **C**, the most commonly chosen option, is therefore incorrect.

Question 13

Option **D** was most commonly chosen. Candidates should be able to recall the formula of simple reactants such as oxygen, O_2, and hydrogen H_2, from the syllabus.

Question 20

The link between pH, acidity and hydrogen ion, H^+, concentration is relatively new to the syllabus and candidates did not appear to be prepared for questions testing this topic. The correct answer was the least chosen option, with option **D**.

Question 21

This question tests understanding of an acidic substance. Each option was chosen equally suggesting that a significant number of candidates were guessing.

Question 22

The solubility of salts was not well recalled. Option **C** was chosen by almost a third of the candidates.

Question 23

Most candidates recognised that statement 4 could not be correct and so few chose options **C** or **D.** The majority of the candidates chose option **B**. Candidates are reminded that they are provided with a Periodic Table. Statement 3 could be disproved by looking, for example, at the relative mass of argon and of potassium.

Question 25

Candidates are reminded that two of the common characteristics of transition elements are a high density and the formation of coloured compounds. Although better performing candidates had no problem with this question, other candidates were much more likely to choose option **B.**

Question 26

This question combined the properties of metals and their uses. Some candidates incorrectly thought that high density would be a suitable property for use in an aircraft and chose option **A**. Other candidates tended to confuse the metals present in stainless steel and chose option **D**.

Question 39

When investigating the rate of a reaction time must be measured. This may be to measure a physical quantity at a specific time or to measure the time taken to reach a specific quantity. If investigating the effect of temperature on the rate, a thermometer must also be used. The other equipment listed in the question may be used but they are not required to be used. For example, the volume of gas could be measured using a gas syringe, but this is not essential. The time taken for effervescence to stop in the reaction could also be monitored, but this is also not essential. Only the thermometer and the stop-watch are needed.

Question 40

Candidates are only provided with the ‘Notes for use in qualitative analysis’ for Paper 5 or Paper 6. They are not provided with these notes in any other paper. The tests on ions and gases are required syllabus knowledge and so candidates must be familiar with their use. Most candidates chose either options **A** or **C** suggesting that knowledge of both the ion tests given is poor.

CHEMISTRY

Paper 0620/21
Multiple Choice (Extended)

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

General comments

Overall, the candidates found this to be an accessible paper although good discrimination between candidates of different ability was shown.

Questions 5, **19**, **22**, **27**, **34** and **38** were of the lowest demand and **Questions 10**, **12** and **13** were the most demanding.

Questions 3, **4**, **7**, **10**, **24**, **28** and **30** showed the greatest discrimination between candidates.

Comments on specific questions

Question 2

Most candidates recognised that energy is used to overcome attractive forces during melting, but other candidates assumed that the temperature would increase during melting and were more likely to choose option **B**.

Question 3

Most candidates recognised that the gas with the greater M_r would take longer to travel down the tube. Some candidates confused the acidic nature of SO_2 and assumed that universal indicator would turn blue. Option **B** was the most commonly chosen option for these candidates.

Question 7

Few candidates incorrectly thought that the ionic compound would conduct electricity when solid and so options **A** and **B** were not often chosen. The third of the candidates who chose option **C** did not recognise that intermolecular forces only occur in molecules, which are covalent rather than ionic substances.

Question 10

Candidates often find calculation questions challenging and this was one of the most demanding questions of this type. Option **B** was the most commonly chosen option. To calculate 32.2%, candidates did not make any attempt to use the equation or the moles of reactants and products or to use a simple ratio.

Question 11

Few candidates chose options **A** or **C**, however many candidates confused the empirical formula with molecular formula and gave option **D** as their answer.

Question 12

Candidates must take care to read the full question, taking particular note of words which have been highlighted in bold. In this question, many candidates missed the word ‘two’ and so chose option **B** which is half the correct value.

Question 13

Most of the candidates who performed less well overall confused the anode and cathode and so suggested either options **A** or **B**. A third of candidates overall confused the electrolysis of copper(II) sulfate using a copper anode with the same electrolysis using graphite electrodes and gave option **C**.

Question 16

Very few candidates chose options **C** or **D**. Some candidates confused endothermic and exothermic reactions and chose option **B**.

Question 24

Questions on the acid-base nature of ammonium salts with sodium hydroxide are often well recalled. Most of the candidates who performed well overall answered this correctly. Other candidates were more likely to think that hydrogen is produced, option **C**. Very few suggested nitrogen or chlorine.

Question 30

This question on the general properties of carboxylic acids discriminated well between candidates. Whereas nearly all of the overall better performing candidates answered this correctly, others appeared to be guessing with all the options being chosen equally.

Question 31

Most candidates recognised that iron loses electrons when it rusts. Some candidates confused the role of zinc in sacrificial corrosion and assumed it promoted rusting rather than protected the iron. Option **B** was the most commonly chosen option for candidates who performed less well overall.

Question 35

Candidates who performed well overall tended to answer this question correctly whereas others appeared to be guessing. Option **B** was the most commonly chosen option overall.

CHEMISTRY

Paper 0620/22
Multiple Choice (Extended)

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

General comments

Overall, the candidates found this to be quite an accessible paper although discrimination between candidates of all abilities was possible.

Questions **2**, **4**, **22**, **29**, **30** and **33** had the lowest demand. **Questions 8** and **10** had the highest demand. There was a good distribution of marks with many candidates doing particularly well.

Questions which require more than one piece of information such as those using a table, or three or four statements tended to discriminate well between candidates of different abilities.

Comments on specific questions

Question 5

The three structures shown are those of graphite, diamond and silicon(IV) oxide. Candidates recognised that all three will have a high melting point but a third did not recognise that graphite is a soft material, (commonly used in the core of a pencil) and chose option **A**.

Question 8

This was one of the more demanding questions on this paper. Few chose options **C** or **D** whereas option **B** was most commonly chosen, suggesting some confusion about the term ‘empirical formula’ compared with ‘molecular formula’.

Question 9

This question discriminated well between candidates. Some candidates chose option **D** suggesting confusion about the steps needed to determine the moles of acid needed for this titration.

Question 10

Candidates who performed well overall had no problems with this question whereas others were more likely to choose one of the incorrect options. Many thought that it is electrons rather than ions that move through the electrolyte during electrolysis and chose option **A**.

Question 12

Option **B** was the most commonly chosen option with almost two-thirds of the candidates who performed less well overall giving this as their answer. On a reaction pathway diagram, the activation energy is shown as a rise in energy representing the increase in energy required i.e., an endothermic process, for the activation energy; statement 3 is therefore correct.

Question 14

Overall, nearly all candidates recognised that increasing the pressure would increase the yield of ethanol in this equilibrium. Candidates who performed less well overall typically ignored or confused the enthalpy change of reaction and assumed that a high temperature would also increase the yield and chose option **D**.

Question 21

Most candidates recalled the trend in density down Group I but candidates who performed less well overall were more likely to reverse the trend in melting points and gave option **D**.

Question 27

Most candidates recognised the need to remove insoluble substances using filtration as an important step in the treatment of domestic water supplies. Chlorine, however, is used to kill harmful micro-organisms in the water rather than to reduce the pH of the water, which is why commonly chosen option **B** is incorrect.

Question 31

Candidates who performed less well overall were more likely to choose one of the acidic oxides, options **C** or **D**, than the basic oxide to neutralise the acidic gases.

Question 40

Candidates should recognise the significant of the decimal place to indicate a higher level or precision in the measurement. They should also recognise which pieces of apparatus measure a range of different volumes and which only measure a fixed volume. Option **D** was the most commonly chosen option.

CHEMISTRY

Paper 0620/23
Multiple Choice (Extended)

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

General comments

Questions 4, **11**, **15** and **28** had the lowest demand.

Questions 6, **7**, **9**, **13**, **19**, **35**, **36** and **39** had the highest demand.

There was a wide distribution of marks with some candidates doing particularly well. Many questions showed strong discrimination between candidates although there was a relatively small number of candidates overall for this paper.

Questions on organic chemistry were not well answered.

Comments on specific questions

Question 2

This question discriminated well between candidates. Candidates who performed less well overall were more likely to choose any of the options than the correct answer. Most of these candidates chose option **C**, assuming that gaseous HBr, with the greater M_r would travel faster.

Question 6

Most candidates recalled that silicon(IV) oxide would have a high melting point. Most also incorrectly thought that it has a structure similar to that of carbon dioxide and chose option **C**.

Question 7

Candidates often find calculation questions the most challenging on the paper and this was one of the most demanding questions of this type. Option **C** was most commonly chosen. To calculate 53.3%, candidates did not make any attempt to use the equation or the moles of reactants and products or any attempt to use a simple ratio.

Question 9

Most candidates confused the electrolysis of copper(II) sulfate using copper electrodes with the electrolysis using graphite electrodes. Option **D** was most commonly chosen. Candidates are reminded that cations are attracted to the cathode and that reduction occurs at the cathode, which may help in deducing the answer to questions like this.

Question 13

The was one of the most challenging questions on this paper. Candidates should take care to use the scale provided when using sections of a thermometer. Over two-thirds of candidates who performed less well overall either mis-read the scale or confused the sign of the enthalpy change for experiment 1 and chose options **A** or **B**.

Question 18

Fewer than a third of the candidates answered this question correctly. The distribution of responses suggests that many candidates were guessing. Candidates are reminded that in an equilibrium, both forward and reverse reactions occur at the same time so there is no complete reaction and therefore no complete conversion of reactants to products.

Question 19

This was a demanding question requiring candidates to apply the definition of a reducing agent to a specific reaction. The distribution of choices suggests many candidates were guessing or were confusing the oxidation of KI with reduction or reducing agents with oxidising agents.

Question 30

A third of candidates chose options **A** or **D** which suggests that they were guessing because the structures paired for those options did not have the same number of carbon atoms. Another third of candidates chose option **C**. This was not an easy question but if the candidates converted the structures given to a skeletal formula they may find it easier to spot structures which are the same.

Question 35

Candidates frequently find questions on polymerisation difficult. Although most candidates recognised that the polymer structure shown could not come from an alkene (option **A**), they did not continue this reasoning to rule out it being an addition polymer and chose option **C**.

Question 36

The reactions of alkanes such as methane were not well recalled. Although there was a slight preference towards the correct answer, all the options were chosen, and there was evidence of guessing.

Question 39

Candidates are provided with Qualitative notes for Paper 5 or Paper 6. They are not provided with these notes in any other paper. The tests on anions and cations are required syllabus knowledge and so candidates must be familiar with their use and the expected observation for negative results. Most candidates chose either options **B** or **C** suggesting that knowledge of the ion tests given is poor.

Question 40

The recall of ion tests was poor. A small majority of the candidates answered this question correctly, but most were more likely to choose options **C** or **D**.

CHEMISTRY

Paper 0620/31
Theory (Core)

Key messages

- Candidates should read each question carefully so they answer the question being asked.
- Candidates would benefit from learning the syllabus definitions of chemical terms, processes and qualitative chemical tests in particular.
- Interpretation of data and the prediction of physical properties using data was generally accurate.
- 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 therefore do not have a specific answer line.

General comments

Candidates must take care to read the whole question. Many questions require candidates to identify a substance which has more than one property such as **Questions 1(a)(ii), (a)(v)** or **2(a)(i)**.

Chemical tests in **Questions 2(c)**, **3(d)(ii)** or **3(d)(iii)**, were not well known and it sometimes appeared that candidates were guessing likely observations such as 'bubbling'. It is recommended that candidates spend more time practising questions of this type.

Sometimes, candidates did not answer the question asked. For example, in **Question 3(b)(ii)** many candidates renamed the electrodes rather than naming the electrolysis products and in **Question 5(a)** candidates described the use of a symbol rather than the arrangement of particles in an atom.

In **Questions 5(b)(ii)**, **6(e)(i)** and **6(e)(ii)** recall of air pollutants, their adverse effects and solutions to the problems caused was generally poorly answered. Adverse effects were often confused with other pollutants on the syllabus.

The descriptions of diffusion within a sealed tube were better than in previous years (**Question 6(f)**) with most candidates identifying the process and the movement down a concentration gradient.

Questions 4(c)(i) and **7(d)** required the addition of chemical names to word equations. These questions were well answered and showed good recall of the reactants in photosynthesis. Few candidates recalled the use of chlorophyll although most recalled the use of sunlight.

Questions on organic chemistry had the highest demand. The formation of ethanol by catalytic addition fermentation and the formation of alkene from petroleum fractions, **Questions 8(b)(i)**, **(b)(ii) and (c)** were not well recalled and many candidates either gave no answer to these questions or stated information already given in the question.

Questions which require candidates to add to a diagram, **Questions 3(b) and 4(a)**, were not attempted by large numbers of candidates. It is recommended that candidates tick-off or strike through the mark allocation for each question so that it is easy to identify any unanswered questions.

Candidates should take time to learn the essential definitions of chemical terms in the syllabus. Many descriptions were too vague or not given at all. For example, in **Question 3(d)(i)**, few candidates recalled that an alkali is a soluble base, with many not mentioning dissolving or aqueous solution at all. In **Question 4(b)(iii)**, most answers were ambiguous or confused solvent with solute.

Comments on specific questions

Question 1

Many candidates confused the structures of the metal, the alloy and the ionic compound.

Candidates should take care to read the question carefully where there is more than one part to the question. For example, **(a)(ii)**, **(a)(v)** and **(a)(vi)**. A small number of candidates did not attempt one or more of the questions in **(a)**, which is unusual when the answers to each are provided as one of a selection of structures.

(a) (i) A small majority of candidates answered this correctly. Many incorrectly suggested the ionic structure (**A**) or the metal (**E**) as best representing an alloy.

(ii) Many candidates suggested **E** or **G**, identifying a substance that conducts electricity when solid and so missing the essential requirement that conduction must only be when molten or in aqueous solution. Candidates must be careful to read the full question.

(iii) Most candidates recognised the representation of diamond as a giant covalent structure.

(iv) Most candidates correctly identified water (**C**) as the product formed in the hydrogen–oxygen fuel cell. A small number of candidates suggested structure **F**, methanol, as the product, perhaps as another compound which contains both hydrogen and oxygen.

(v) This question was not well answered. Candidates must take care to read the whole question. For this question the answer is a compound **and** has a high melting point. Most candidates gave an answer which was either a compound only, **B**, **C**, or **F**, or had a high melting point only, **E**, **D** or **G**.

(vi) This question required candidates to recall that methane is a gas responsible for global warming **and** its structure. Only a small majority of candidates answered this correctly with this question discriminating well between candidates.

(b) Most candidates gained some credit, usually for the two bonding electrons between each hydrogen atom and the oxygen atom. The most common error was to add six or just two non-bonding electrons to the outer shell of oxygen. A small number of candidates gave covalent bonds containing three electrons or added six non-bonding electrons to each hydrogen atom.

Question 2

Most candidates handled the data provided well. The qualitative tests and the solubility rules were not so well recalled.

(a) (i) Most candidates answered this question correctly although some did not read the full question and suggested magnesium which had the lowest mass on the table but is not a non-metal. A small number of candidates suggested ‘other elements’.

(ii) Candidates could give either of the two Period 4 elements on the list. Candidates who performed less well overall were more likely to confuse Period 4 with Group IV and suggest ‘carbon’.

(b) This question discriminated well between candidates. Candidates who performed less well overall commonly suggested ‘magnesium oxide’, a few confused magnesium with manganese and some gave a name which was ambiguous because the spelling was poor. Candidates should use the table provided or their Periodic Table to check their spelling of chemical names.

(c) Chemical tests were not well known. Although Qualitative analysis notes are provided on Papers 5 and 6, they are not provided on Papers 3 or 4 and the tests are expected syllabus knowledge. Fewer than one candidate in five described the formation of a white precipitate and almost one candidate in six did not attempt the question at all.

(d) The solubility rules were not well recalled. Calcium carbonate was a common incorrect answer. A large number of candidates did not give the name of a calcium compound, for example ‘sodium chloride’ or ‘table salt’. The most common correct answers were ‘calcium chloride’ and ‘calcium nitrate’. Almost one candidate in six did not attempt this question.

(e) Almost all candidates gave a sensible suggestion for the melting point of potassium. When provided with a table such as Table 2.2, candidates should use the descriptions given to help guide their own answer to this question. A small number of candidates stated that ‘there would be no reaction’.

(f) Although the question should be a simple choice between the density increasing or decreasing down the group, many candidates did not answer this question, and many answered a question that was not asked. Information about the trend in melting point or reactivity of the metals was often given.

(g) Most candidates identified the ratio of ‘sodium’ to ‘sodium hydroxide’. The formula of hydrogen as H_2 was not well known with 2H a more common answer. Many incorrectly identified the second product as water and gave H_2O.

Question 3

Overall, this question discriminated well between candidates. It was also one of the more challenging questions overall. Candidates should take care to answer all the questions.

(a) This question discriminated well between candidates. Candidates who performed less well overall did not appear to understand the term ‘ore’ and suggested either a property of aluminium or they gave the name of another metal such as ‘iron’. Few were able to spell bauxite correctly.

(b) (i) Over a third of candidates did not attempt this question. Where no answer lines are provided, candidates should use the mark allocation, such as ‘[1]’ and perhaps ‘tick-off’ the question once complete. Those that did attempt the question tended to choose either the incorrect electrode or a wire rather than the solid shaded area representing the electrode surface. When identifying an electrode, candidates should draw a label line to an area where the electrolysis would take place rather than the wire leading to the electrode.

(ii) Candidates who performed less well overall struggled with this question. One of the most common answers was to not name the products but to give the alternative names for the electrodes as ‘anode’ and ‘cathode’. Some did not attempt the question at all, some reversed the products or suggested ‘oxide’ rather than ‘oxygen’ as the product.

(c) A large number of candidates incorrectly stated that aluminium is a ‘non-conductor of electricity’ or stated that is was a ‘conductor’ but did not state that it was a conductor of electricity.

(d) (i) Few candidates could recall the meaning of the term ‘alkali’. Many candidates gave an answer in terms of pH or indicator colour but did not mention solubility or dissolving of a base.

(ii) One in ten candidates did not attempt this question. The use of indicator paper was poorly described and some candidates incorrectly described the use of litmus. Many candidates stated colours such as ‘if it’s red it’s acid’ or ‘it will go blue’ but did not describe the use of a colour chart to compare the observed colour with a specific pH.

(iii) The colour change of methyl orange was not well known. A few candidates identified one or other of the colours or reversed the colours but few answered this fully correctly.

Question 4

This was one of the best answered questions. Most candidates gained some credit on the topic of chromatography. Some candidates found the specific terminology from the syllabus difficult to describe. It is suggested that clear, full definitions of terms such as solvent, solute and solution are regularly practiced.

(a) Many candidates were close but circled too many atoms. Many circled additional hydrogen atoms or neighbouring carbons which were not part of the C=C system. A small number circled a methyl group or the hydroxyl group.

(b) (i) Nearly all candidates identified the plant with the greatest number of coloured compounds.

(ii) Nearly all candidates identified the two plants containing exactly the same coloured compounds.

(iii) Many candidates described the use of solvents in chromatography rather than describing what a solvent is. Many also confused the terms solvent, solute and solution or the difference between a reaction mixture and a physical mixture.

(c) (i) Most candidates recalled the reactants in photosynthesis. This question was well answered.

(ii) Few candidates recalled the need for chlorophyll in photosynthesis. The most common answer was ‘sunlight’ which although essential for photosynthesis is a source of energy and not a substance.

Question 5

This question was generally well answered. Candidates should read the question carefully to make sure they are answering the question asked. Many confused the position of the proton in an atom with a description of the position of the proton number on a nuclide symbol.

(a) Many candidates were unclear what was meant by the ‘position of the electrons, neutrons and protons in this atom’. Many described the use of the nuclide symbol and gave answers such as ‘protons are the bottom number’. Some described electrons being ‘on the outer shell’ which is only partially correct because electrons also occupy inner shells. Some also suggested that ‘electrons orbit the atom’ which incorrectly suggests that electrons are not part of the atom but surround it. The electrons should be described as orbiting the nucleus of the atom. Some candidates thought that different particles occupied the different shells.

Most candidates used the symbol to deduce the number of protons and neutrons with a small number going on to give the electron configuration.

(b) (i) Most candidates correctly balanced this equation.

(ii) Only a quarter of candidates recalled that carbon monoxide is toxic. Most incorrect answers were confusions with other air pollutants such as particulates or oxides of nitrogen.

(c) Most candidates answered this correctly, but it was not as well answered as similar questions in previous years. Some candidates omitted the ‘Cr’ or mis-counted the number of carbon atoms. A small number gave their answer in an inappropriate format such as including commas between elements or using ‘CR’ for chromium.

(d) This question was well answered. A small number of candidates calculated each row correctly but did not include the ‘46’ given on the top row within their final answer.

(e) This question was poorly answered. Candidates should be clear and careful when describing what is happening in redox reactions. Many stated that it’s chromium rather than chromium(III) oxide that is being reduced. Some answered a question that was not asked by describing what is happening to other elements.

Question 6

The effect of particle size of solids, the pressure of gases and the temperature on the reaction rate was well recalled although candidates must also be careful not to confuse reaction rate with reaction time. The adverse effect of air pollutants was not so well remembered and few recalled methods to reduce the sulfur dioxide released from fossil fuels.

(a) This question was not well answered. The state symbol letter must be clearly seen to be a lowercase ‘s’. Many candidates wrote an ambiguous letter which could easily be confused as a ‘g’. A significant number added additional element symbols such as ‘O’ or ‘O_2’.

(b) The majority of candidates identified the time where the curve flattened as the time taken for the reaction to finished. The most common errors were to suggest 140 s or 80 s.

(c) Most candidates recognised that powdered sulfur would react more quickly than large pieces of sulfur.

(d) (i) Most candidates gained full credit here. Some described the reaction time rather than the reaction rate and some described other effects such as the pressure of the gas when temperature rise. Only a small number confused the direction of change of rate of reaction.

(ii) Most candidates recognised a correct unit for concentration, but a quarter of candidates chose one of the other options.

(e) (i) The adverse effects of the air pollutant sulfur dioxide were not well recalled. Only a large minority of candidates recalled acid rain or an effect of acid rain on the environment.

(ii) Flue-gas desulfurisation was not well known. Almost one in five of the candidates gave no answer to this question. Many restated the use of low-sulfur fuels or suggested an alternative fuel. A small number of candidates gave detailed answers including the use of calcium oxide.

(f) Most candidates recognised the process as diffusion and many described the movement from a position of high concentration to one of low concentration. Many candidates did not mention particles at all. The movement, spreading and collision or particles should be described.

Question 7

This question was often well answered with most candidates showing good understanding of metal reactivity and properties. Candidates should take care to avoid repeating the question as their answer and to give a more complete answer when asked to give a reason for their answer such as for **7(b)(ii)**.

(a) Some candidates restated the properties in the question, which were ignored because the question asked for ‘other physical properties’. A small number described chemical properties or uses of iron.

(b) (i) Most candidates recalled the essential conditions for rusting.

(ii) Most candidates recognised that iron(III) oxide is a basic oxide but did not give a suitable reason. Some described the use of an indicator rather than stating that iron(III) oxide is a metal oxide and metal oxides are basic.

(iii) Most candidates suggested a suitable method of preventing rusting. Some answers were too vague such as ‘covering’ or gave answers which were impractical such as keep in a dry place or away from oxygen.

(c) Many candidates were unclear where sodium and silver fit in the reactivity series, often placing silver above copper or calcium above sodium. Some candidates included a metal which was not on the list such as zinc or magnesium.

(d) This question was well answered with many candidates stating both products. A small number of candidates swapped the names of the reactants to give incorrect answers such as ‘calcium acid’ or ‘nitric carbonate’. Some incorrectly suggested ‘calcium nitrite’ rather than calcium nitrate.

Question 8

Questions on organic chemistry were poorly answered. Many candidates gave no answer for the last three question parts, **(b)(i)**, **(b)(ii)** and **(c)**.

(a) (i) Most candidates identified the two compounds from the same homologous series.

(ii) Few candidates gave a complete answer to this question. Many gave answers which were close to the correct answer but were ambiguous. For example, many candidates stated that ‘compound **V** contains carbon and hydrogen’. This is a correct statement but does not explain why **V** is an alkane because all the substances listed contain carbon and hydrogen. The word ‘only’ must be present. Similarly, the statement that ‘it has single bonds’ is also correct for the other substances which are not alkanes. Again, the word ‘only’ or ‘saturated’ must be present.

(iii) Only a minority of candidates gave the name ‘carboxylic acid’ as the name of the homologous series. Some were close and suggested ‘carboxylate’ or a similar name but most suggested ‘alcohol’ or ‘alkane’ and one in nine candidates gave no answer.

(b) (i) Some candidates recalled the reaction conditions for the manufacture of ethanol by the catalytic addition of steam to ethene. A wide range of incorrect values were often suggested.

(ii) This question was not well answered with many not giving any answer. Some restated the method of ethanol manufacture given in the question.

(c) Some candidates confused fractional distillation and cracking and described how a fractionating column was used. A very small number of candidates stated that the process was called ‘cracking’ but did not describe how this process occurred, or the reactant needed.

CHEMISTRY

Paper 0620/32
Theory (Core)

Key messages

- Questions where candidates had to match the structure to a given statement were answered well.

- Questions requiring simple answers to calculations were usually well answered as were questions involving balancing equations. Candidates were able to easily calculate the relative molecular mass of a given compound as in **Question 5(d)**.

- Questions on the more detailed aspects of the kinetic particle theory were answered well. However, there was a tendency for some candidates to answer this question too generally. Many candidates forgot to mention the words ‘particles’ or ‘molecules’ in their answer.

- It is important that candidates read the question carefully to understand what exactly is being asked. Practice of reading and interpreting questions that involve data handling should also be prioritised.

- The answering of chemical test questions was not done well. The candidates’ answers showed many large gaps in their knowledge. This is a part of the syllabus that needs to be practiced and used in classroom tests more often. Candidates struggled with ‘Describe a test for chloride ions’ as in **Question 2(c)**.

- Organic questions were answered well and some candidates could draw the structures of organic compounds. Some candidates could ‘draw the displayed formula for a molecule of ethene’ as in **Question 4(a)(i)**.

- Candidates struggled with the reactivity series question as in **Question 7(f)**. They could not put the given metals in their correct order of reactivity. More work on this specific part of the syllabus should be done with candidates.

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. Nearly all candidates were entered at the appropriate level. It was evident that many candidates are now using past paper practice 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 2(e)** which asked the candidates to ‘suggest why it is difficult to predict the density of rubidium’. Many candidates answered this question stating that ‘rubidium’s density could not be predicted because of its explosive reaction with water’ rather than using the data in the given table as they were asked to do. Another misinterpretation was seen in **Question 4(b)(ii)** where it asked, ‘State two characteristics of a mixture’. Some candidates thought that this meant they needed to answer using the characteristics of the mixture used in the previous chromatography experiment and not the general characteristics of a mixture. Candidates also struggled with the longer question about the atomic structure of an atom of sulfur. Many candidates misread this question and thought that ‘the position of the electrons, neutrons and protons in the atom’ were where the mass number and atomic number were in the symbol shown rather than in the atom of sulfur itself. The balancing of equations was good, demonstrating that candidates had practiced these as part of their revision. Definitions from across the syllabus were reasonably well answered. Candidates had spent time learning them and had revisited them during their revision time.

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. This showed much practice and revision of past paper questions. Data handling type questions could have been answered better. Candidates often 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 most accessible question on this paper and performed well on it. They especially did well on **(a)(iii)**, **(a)(v)** and **(b)**.

(a) (i) Many candidates struggled with this first question. **E** or **G** were common errors.

(ii) Candidates found this question particularly challenging. There were not many correct answers. **A** was a very common incorrect answer. The word ‘compound’ was not used here.

(iii) This question was very well answered.

(iv) Many candidates struggled with this question and thought that the correct answer was **D**.

(v) This question was well answered. A few candidates thought that it was **B** or **G**.

(vi) Candidates found this question hard and there were not very many correct answers. **F** was the most common incorrect answer.

(b) Candidates did well on this question. Most could draw the bonding pairs of electrons between the atoms. Putting extra electrons on the hydrogen atoms was the most common mistake.

Question 2

Candidates found this question hard, especially the naming of the compound, the chemical test question and the prediction of the density of rubidium. However, most candidates could use the information in the table to answer questions about ions and balance the symbol equation.

(a) (i) Most candidates answered this question correctly. A few did not read the question and answered with the highest concentration instead of the lowest.

(ii) Candidates found this question slightly more challenging and could not identify the correct ion.

(b) Some candidates struggled with this and could not name the compound correctly. A very common incorrect answer was sodium sulfide. More practice is needed on answering these types of questions.

(c) This question was very poorly answered with many candidates writing the wrong test, getting mixed up between tests or not writing a chemical test at all. A few candidates selected the correct test but then wrote the incorrect observations. More practice and learning of the chemical tests is needed.

(d) Solubility rules caused lots of problems. Candidates found this question very challenging and there were not many correct answers.

(e) Candidates found this question very challenging particularly the first part. The question stated that candidates must use the information in the table. However, many candidates did not do this. For the first part many candidates said that it was difficult to predict the density of rubidium because it was too explosive with water, or that its density varied. Not many candidates used the data in the table to get the correct answer. Candidates did better on the second part of this question but again they did not use the trend in the table to form their answers.

(f) Candidates found this question hard and many thought the answer was that the melting point of the Group I elements increases down the group.

(g) Most candidates performed well here with many correct answers. They could easily balance the given equation.

Question 3

Candidates found this question particularly challenging including the labelling of the anode, colour changes of indicators and the formula of the ion present in all acids.

(a) (i) Candidates struggled to answer this question correctly and there were many ‘no responses’. Arrows were seen many times to the wires instead of to the actual anode itself. Candidates need to take more care when labelling pieces of apparatus.

(ii) This question was not well answered. Many candidates could not ‘name a non-metal that can be used as the anode’. Lots of different incorrect elements were seen as answers here.

(iii) This question discriminated well between candidates. Many candidates could name the product formed at each electrode. Some got ‘chloride’ confused with the correct ‘chlorine’. A few candidates misread the question and thought that the electrolysis was in aqueous solution and so used hydrogen as one of their answers.

(b) Candidates found this question the hardest on the paper and few correct answers were seen. Many candidates were too vague and general. The most popular incorrect answer was to suggest that ‘magnesium is a reactive metal’.

(c) Candidates found this definition question hard and there were not many correct answers. Many candidates did not know that alloys were ‘mixtures’ and that they had ‘metals’ in them. More revision needs to be carried out on these types of definitions.

(d) (i) Few candidates answered this question correctly.

(ii) Some candidates performed well here and stated the correct answer. There were candidates that thought the gas produced was ‘carbon dioxide’.

(iii) This question was not well answered. Candidates struggled to recall the correct colour change of the indicator. Some candidates did get the correct colour change but it was the wrong way around.

(iv) Candidates found this question hard and were not able to ‘name the indicator that can be used to determine the pH’. Many candidates suggested ‘litmus paper’ and ‘methyl orange’ as incorrect answers here.

Question 4

This was the hardest question on the paper and discriminated very well between candidates. Candidates struggled with all the questions especially **(b)(i)** and **(b)(ii)**.

(a) (i) This question was not very well answered. The only candidates that could draw the correct structure of ethene were those that went onto achieve the highest marks on this paper.

(ii) Candidates did slightly better on this question. However, many repeated ‘carbon dioxide’ from the question stem and some thought ‘hydrogen’ was one of the correct answers.

(b) (i) Candidates did not do very well on this labelling question and there were not many correct answers. This question had a very high level of ‘no responses’. Many candidates did not know where to put the mixture of coloured compounds at the start. Some candidates thought that the level of the solvent at the start should be either below the chromatography paper or at the same level as where the initial spot of colour was placed.

(ii) This question was not very well answered. Many candidates had not learned ‘two characteristics of a mixture’ and some got them mixed up with the characteristics of a compound. Other candidates thought that the question meant they needed to answer using the characteristics of the mixture used in the previous chromatography experiment and not the general characteristics of a mixture.

Question 5

Candidates did much better on this question than **Question 4**. They did well on **(b)(ii)** and **(d)**. However, some candidates found the longer **(a)** more challenging.

(a) Most candidates could deduce the number of neutrons and protons in the sulfur atom shown. Many candidates struggled with the electronic configuration of the same atom. However, a large proportion of candidates misread this question and thought that ‘the position of the electrons, neutrons and protons in the atom’ were where the mass number and atomic number were in the symbol shown rather than in the atom of sulfur itself.

(b)(i) Candidates struggled to state an adverse effect of sulfur dioxide. Many stated wrongly that it was a greenhouse gas or that it was toxic.

(ii) Candidates did much better on this question and were able to complete and balance the given symbol equation.

(c) Candidates did well on this question and many had practiced deducing the molecular formula of a compound. The elements can be placed in any order but the numbers must be subscript and not superscript.

(d) Most candidates were able to calculate the relative formula mass of the compound of sulfur correctly.

Question 6

This question discriminated well between candidates. Candidates found **(b)(i)** and **(d)(ii)** particularly challenging.

(a) Only candidates that went onto achieve the highest marks on this paper could add the missing state symbols to the given equation.

(b)(i) Many candidates struggled with this question and there was a high level of ‘no responses’.

(ii) Candidates were able to use the graph to deduce the correct mass.

(c)(i) Many candidates answered this question correctly. The most common error was to give an answer that was not comparative such as ‘the reaction is slow’ or ‘the reaction is fast’. Some candidates also confused rate with the time of reaction and stated incorrectly that ‘less time would be taken’ or ‘more time would be taken’.

(ii) Most candidates could correctly ‘choose the correct unit of concentration from the list’.

(d)(i) Many candidates could choose the correct pH for an acid.

(ii) Candidates found this question on ways of reducing pollution very hard. There were not many correct answers.

(e) Some candidates did very well on this question showing that they had been practicing past paper questions on the kinetic particle theory. The main mistake was not using ‘particles’ or ‘molecules’ in their answer or forgetting that it was ‘diffusion’.

Question 7

Most candidates were able to state at least one correct physical property of iron and knew which test-tube contained the iron nail that was most likely to rust. However, candidates struggled to describe how the given equation showed that copper(II) oxide is reduced.

(a) Most candidates were able to state at least one correct physical property of iron. However, many candidates just repeated one or more of the physical properties mentioned in the question and so did not gain credit for those.

(b) (i) Most candidates performed well here with many correct answers.

(ii) This question discriminated well between candidates. Not all candidates could 'choose from the list the compound in rust'.

(c) Candidates found this question very hard and few correct answers were seen.

(d) Many candidates stated copper(II) chloride. However, they were less likely to identify water. The most common incorrect answer was hydrogen.

(e) Candidates found this question very challenging and were not able to describe how the equation given shows that copper(II) oxide is reduced. The most common incorrect answer was 'copper loses oxygen'.

(f) Some candidates had not learned the reactivity series and so were not able to put the stated five metals into a correct order of their reactivity. Some candidates put them in order but the wrong way around.

Question 8

Candidates found the last question on this paper very challenging. They particularly struggled on the very last part which was to 'state two types of reaction of the alkanes'.

(a) (i) Candidates struggled on this question mainly because they did not read the question correctly and wrote down 'increases' instead of 'increases down the group' or 'increases with the number of carbons atoms'.

(ii) This was one of the hardest questions on this paper. Many candidates could not recall or deduce the general formula for carboxylic acids.

(b) (i) Most candidates were able to correctly give at least one of the two correct answers.

(ii) Candidates struggled to choose the correct answer for this question.

(c) (i) Few candidates could give at least one definition of a homologous series. Some candidates gave the definition for an isomer or wrote down points about metals.

(ii) 'Ionic bonding', 'single bonds' or 'double bonds' were all seen as incorrect answers to this question.

(iii) Candidates particularly struggled on this last question and could not 'state two types of reaction of the alkanes'. Correct answers of 'combustion', 'cracking' and 'substitution with chlorine' were seen but only in a very few cases.

CHEMISTRY

Paper 0620/33
Theory (Core)

Key messages

- Questions where the candidates had to match the structure to a given statement were answered well.
- Questions requiring simple answers to calculations were usually well answered, as were questions involving balancing equations. Candidates were able to easily calculate the relative molecular mass of a given compound as in **Question 5(d)**.
- Questions on the more detailed aspects of the kinetic particle theory were answered well. However, there was a tendency for some candidates to answer this question too generally. Many candidates forgot to mention the words 'particles' or 'molecules' in their answer.
- It is important that candidates read the question carefully to understand what exactly is being asked. Practice of reading and interpreting questions that involve data handling should also be prioritised.
- The answering of chemical test questions was not done well. The candidates' answers showed many large gaps in knowledge. This is a part of the syllabus that needs to be practiced. Candidates struggled with 'Describe a test for sulfate ions' as in **Question 2(b)**.
- Organic questions were answered well. Many candidates could 'Complete the word equation for the complete combustion of ethane' and could 'Draw a circle around the alcohol functional group' as in **Question 4(c)**.
- Candidates struggled with the reactivity series question as in **Question 7(d)**. They could not put the given metals in their correct order of reactivity. More work on this specific part of the syllabus should be done with candidates.

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. Nearly all candidates were entered at the appropriate level. It was evident that many candidates are now using past paper practice 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(a)(ii)** which asked the candidates to 'State the trend in the boiling point of this homologous series as the number of carbon atoms increases'. Many candidates answered this question stating the fact that the boiling point decreases as they had read the data given incorrectly. Candidates also struggled with the longer question about the atomic structure of an atom of phosphorus. Many candidates misread this question and thought that 'the position of the electrons, neutrons and protons in the atom' were where the mass number and atomic number were in the symbol shown rather than in the atom of phosphorus itself. The balancing of equations was good, demonstrating that candidates had practiced these as part of their revision. Definitions from across the syllabus were reasonably well answered. It was evident that candidates had spent time learning them and had revisited them during their revision time.

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. This showed practice and revision of past paper questions. Data handling questions were not answered well. Candidates often 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, which ensured concise answers. These candidates were less likely to write vague statements or contradict themselves.

Comments on specific questions

Question 1

Candidates found this first question one of the most accessible questions on the paper and performed reasonably well. They especially did well on **(a)(iii)**, **(a)(vi)** and **(b)**.

(a) (i) Candidates found this first question very hard. **E** or **F** were common errors.

(ii) Candidates did better on this question, particularly those candidates that went onto achieve the highest marks on this paper.

(iii) This question was very well answered.

(iv) Candidates found this question particularly challenging. There were not many correct answers. **D** was a very common incorrect answer. The word 'compound' was not used here.

(v) Many candidates struggled with this question and thought that the correct answer was **E** or **F**.

(vi) This question was well answered. A few candidates answered **D**.

(b) Candidates did well on this question. Most could draw the bonding pair of electrons between the two atoms and add the six non-bonding electrons on the given chlorine atom. Putting extra electrons on the hydrogen atom was the most common mistake.

Question 2

Candidates found this question more challenging than Question 1, especially the chemical test question, stating the formula of a compound and choosing from the list the salt that is insoluble in water. However, most candidates could use the information in the table to answer questions about ions. Many candidates were able to complete and balance the given symbol equation.

(a) (i) Most candidates answered this question correctly. A few did not read the question and answered with the highest concentration instead of the lowest.

(ii) Candidates found this question slightly more challenging and could not identify the correct ion.

(b) This question was very poorly answered with many candidates writing the wrong test, getting mixed up between tests or not writing a chemical test at all. A few candidates selected the correct test but then wrote the incorrect observations. More practice and learning of the chemical tests is needed.

(c) Many candidates struggled with this and could not state the formula of the compound formed from ammonium ions and chloride ions correctly. More practice is needed on answering these types of questions.

(d) Candidates found recall of the solubility rules very challenging and there were few correct answers.

(e) Many candidates were able to 'predict the hardness of potassium'. However, they struggled to use the trend in the table to form their answers.

(f) Most candidates performed well here with many correct answers. Some candidates did not know the correct formula for hydrogen and incorrectly used 'H' or '2H' in their answers.

Question 3

Candidates found this question the hardest question on the paper. They particularly found naming the inert metal that can be used for the electrodes, naming the products formed at each electrode and naming the ion which causes a solution to be alkaline challenging.

(a) (i) Candidates struggled with this definition question and only the better performing candidates gained credit here. Some stated 'by an electric current' or 'by electricity' but hardly any referred to the 'breaking down of an ionic compound' or 'decomposition of an ionic compound'.

(ii) This question was one of the least well answered on this paper. Many candidates could not 'Name an inert metal that can be used for the electrodes'. Lots of different incorrect metals were seen.

(iii) Many candidates struggled on this question. They could not name the product formed at each electrode. Some got 'bromide' confused with the correct 'bromine'. A few candidates misread the question and thought that the electrolysis was in aqueous solution and so used hydrogen as one of their answers.

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

(ii) Many candidates chose the correct pH value of an alkaline solution.

(iii) This question was not as well answered. Candidates struggled to recall the correct colour change of the litmus. Some candidates got the correct colour change but it was the wrong way around.

(c) (i) Candidates found this question hard and there were not many correct answers for this chemical test question. 'Hydrogen' was a very common incorrect answer.

(ii) Few candidates answered this question correctly and a common incorrect answer was 'cracking'

Question 4

Candidates generally performed well on this question. They especially did well on **(a)(i)** and **(a)(ii)** but found **(b)(iii)** and **(c)** more challenging.

(a) (i) Many candidates could 'complete the word equation for photosynthesis'.

(ii) This was a very well answered question.

(b) (i) Candidates struggled to correctly 'Name this method of separation' and other incorrect separation methods were seen.

(ii) This was answered well by most candidates.

(iii) Candidates found this definition question very challenging and not many correct answers were seen. Some candidates got very mixed up and thought that a 'solution' was the 'solid that dissolved'.

(c) This question was not very well answered and few candidates could 'Draw a circle around the alcohol functional group'.

Question 5

Candidates found this question less challenging than other questions on this paper. They did very well on **(b)** and **(d)**. However, some candidates found the longer **(a)** more challenging.

(a) Most candidates could deduce the number of neutrons and protons in the phosphorus atom shown. Many candidates struggled with the electronic configuration of the same atom. However, a large proportion of candidates misread this question and thought that 'the position of the electrons, neutrons and protons in the atom' were where the mass number and atomic number were in the symbol shown rather than in the atom of phosphorus itself.

(b) Most candidates performed well here, with many correct answers. They could easily balance the given equation.

(c) Candidates did well on this question and many had practiced deducing the molecular formula of a compound. The elements can be placed in any order but the numbers must be subscript and not superscript.

(d) Most candidates were able to calculate the relative formula mass of the compound of phosphorus correctly.

(e) Few correct answers were seen. Most candidates did not know 'one source of phosphates in river water'.

Question 6

This question discriminated well between candidates. Candidates found **(b)(ii)** particularly challenging.

(a) Most candidates could 'State the meaning of the state symbol (aq)'.

(b) (i) Candidates did well on this question and were able to use the graph to deduce the correct mass.

(ii) Candidates found this question very challenging and the hardest question in this part. They found it hard to 'Explain how the graph shows that the calcium carbonate is in excess' and could not work out that there was calcium carbonate left at the end of the reaction.

(iii) Most candidates realised that the line would be steeper as the temperature was higher than the first experiment so the rate of reaction would be faster. Most candidates knew that the line would start at 10 g and then go to the left of the original line as it was faster. However, not as many candidates realised that the line would also level off at 1 g and it would get there faster than the original line.

(c) (i) Many candidates answered this question correctly. The most common error was to give an answer that was not comparative such as 'the reaction is slow'. Some candidates also confused rate with the time of reaction and stated incorrectly that 'more time would be taken'.

(ii) Most candidates could correctly 'Choose the correct unit of concentration from the list'.

(d) Some candidates did very well on this question showing that they had been practicing past paper questions on the kinetic particle theory. The main mistake was not using 'particles' or 'molecules' in their answer or forgetting that it was 'diffusion'.

(e) Another definition question that candidates found particularly challenging. Common incorrect answers were just to use the term 'energy' instead of 'thermal energy' or 'heat' and to use the correct definition for exothermic instead of the asked endothermic.

Question 7

Most candidates were able to state at least one correct physical property of chromium and knew how coating an iron object with plastic prevents the iron from rusting. However, candidates struggled to describe how the given equation showed that zinc oxide is reduced and to state the chemical name of rust.

(a) Most candidates were able to state at least one correct physical property of chromium. However, many candidates just repeated one or more of the physical properties mentioned in the question which was not creditworthy.

(b) (i) None of the candidates knew the 'chemical name of rust'.

(ii) Most candidates were able to state that oxygen and water is needed for rusting. Fewer could explain that coating with plastic stopped the oxygen and water reaching the surface of the iron object.

(c) Many candidates gave chromium sulfate; fewer knew hydrogen. The most common incorrect answer was water.

(d) Some candidates had not learned the reactivity series and so were not able to put the stated five metals into a correct order of their reactivity. Some candidates reversed the order.

(e) Candidates found this question very challenging and were not able to describe how the equation given shows that zinc oxide is reduced. The most common incorrect answer was ‘zinc loses oxygen’.

Question 8

Candidates found the last question on this paper very challenging. They particularly struggled on the very last question which was to ‘define the term polymer’.

(a) (i) Most candidates performed well here with many correct answers.

(ii) Most candidates could answer this question using the information in the given table.

(iii) This was one of the hardest questions on this paper. Many candidates could not recall or deduce the general formula for the alkane homologous series.

(b) Candidates found this question much easier and most were able to correctly give at least one of the products.

(c) (i) Few candidates could give at least one condition for cracking.

(ii) Candidates answered this question well and most knew another ‘use of the diesel oil fraction’.

(d) Candidates particularly struggled on this last question and could not ‘define the term polymer’. Correct answers of ‘large molecules’ and ‘built up from many monomers’ were seen in very few cases.

CHEMISTRY

Paper 0620/41
Theory (Extended)

Key messages

- Candidates should be aware of the importance of correctly spelling technical terms used in Chemistry. The following were often spelt incorrectly: fermentation, chromatography, galvanising, amphoteric.
- Poor handwriting continues to be a problem. If a candidate's answer cannot be read, then the answer cannot gain credit. To change an answer, the original answer should be crossed out so that it can no longer be seen and the new answer should be written. Many candidates tried to write the new answer on top of the original answer resulting in illegibility.
- The symbols for the elements are shown on the Periodic Table, which is part of the paper. Errors in use of upper case and lower case in writing symbols were common. The formulae of compounds should never show charges.
- If the **name** of a substance is asked for, it is an error to give a **formula**.

Comments on specific questions

Question 1

(a) This was answered well. The most common error was combustion.

(b) Candidates found this the most challenging part of **Question 1**. Many candidates seemed to think they were supposed to be obtaining sodium chloride rather than water. Thus evaporation and crystallisation were the most common wrong answers. Electrolysis and fractional distillation were also seen.

(c) This was answered quite well.

(d) This was answered quite well. Cracking and distillation were common errors.

(e) This was answered well.

(f) This was answered quite well. Fractional distillation was seen occasionally.

(g) This was answered quite well.

Question 2

This question was answered well by most candidates. The most common error was to give the mass number of sulfur as 32. O and Ar were common wrong symbols. The charge was sometimes missing or given as –.

Question 3

(a) The formula of sodium fluoride was often incorrect. NaF_2 and Na_2F were common. The elements were often shown with charges. NA and na were occasionally seen as the symbol for sodium. Fluorine was occasionally seen as F, F*l*, f or f_2.

(b) (i) This was answered poorly. ‘Moving ions’ was given as an answer as frequently as ‘moving electrons’. The term ‘free’ has no meaning when applied to electrons and should be avoided. ‘Delocalised electrons’ and ‘sea of electrons’ are insufficient explanations if mobility is omitted. Candidates who stated that ‘sodium is a metal’ should be aware that an explanation requires a reason why metals such as sodium conduct electricity.

(ii) This was answered well. Some candidates used all dots or all crosses. In some cases it was unclear whether the electrons were crossed out or not. If the candidate thinks that crossings out have made a diagram unclear, it is advisable for them to redraw the diagram.

(iii) It was essential for answers to refer in some way to the boiling point, the melting point and the temperature of –200 °C. Reference to the boiling point was most likely to be omitted. ‘The temperature is higher than boiling point and lower than melting point’ was a common error. Many candidates struggled with negative numbers.

(iv) It was often unclear which substances the candidates were referring to in their answers. Many referred only to sodium fluoride without any reference to fluorine. A large number of candidates did not use comparative terms to explain why sodium fluoride had a higher melting point than fluorine.

There were many contradictory statements such as:

- ionic bonds between atoms
- ionic bonds are strong intermolecular forces
- intermolecular forces between atoms.

A very common misunderstanding is that ‘covalent bonds are weak’ or that ‘covalent bonds are weaker than ionic bonds’.

The term ‘forces’ instead of ‘forces of attraction’ or ‘bonds’ was often used.

(c) (i) There were many very good answers, giving the syllabus definition of electrolysis. The word ‘ionic’ was sometimes missing.

(ii) This was answered reasonably well. H^+ and/or e^- were often missing from the left hand side of the equation. Formulae other than H_2 were often seen as the product.

Question 4

(a) Many answers were accurate repetitions of the syllabus statement.

Common errors included:

- the forward reaction is equal to the reverse reaction (no reference to rate)
- the concentrations of reactants and products are equal (‘equal used instead of ‘no longer changing’)
- the reactants and products are constant (no reference to concentration).

(b) (i) The wording of the answers often omitted reference to ‘number’ or ‘moles/molecules’ or ‘both sides/reactants and products’. Some suggested that constant temperature was the reason for the position of equilibrium not changing.

(ii) Very few candidates made any reference to iodine, which resulted in poor performance. Some stated that the position of equilibrium shifted to the right despite the information in the question.

(c) Many candidates made no reference to thermicity. ‘Exothermic’ was the most common wrong answer.

(d) Oxidation numbers are numbers. They must have a + or – sign in front of them. The only exception to this is zero. Many answers were not numbers. Relative atomic masses or relative molecular masses were seen occasionally.

(e) (i) This was frequently omitted by candidates, presumably because they did not see the question. The majority of those who attempted the question recognised the transition metal as being a suitable catalyst.

(ii) This was answered reasonably well. Common errors were that equilibrium shifts in either direction.

(iii) This was answered reasonably well. Some candidates commented on rate rather than activation energy.

Question 5

(a) (i) Candidates should be aware that all nitrates are soluble in water and that all sodium, potassium and ammonium salts are soluble in water.

Lead(II) nitrate was a common correct answer. Lead(II) chloride or lead(II) iodide or lead(II) sulfate were also seen. Soluble bromides were less common. Silver bromide was the most common error in choosing a soluble bromide. The solutions occasionally contained neither lead ions nor bromide ions.

(ii) The most common error was a description of crystallisation. Those who mentioned filtration frequently omitted to wash or dry the residue.

(iii) Many candidates were unaware that an ionic equation for a precipitation reaction has aqueous ions on the left hand side and a solid precipitate on the right. The equation must be balanced.

Common errors included:
- wrong charge on the lead ion (usually Pb^+) or lack of charges on either 'ion'
- wrong formula of the bromide ion e.g., Br_2^-
- lack of balancing
- an attempt (almost always incorrect) at a non-ionic equation
- omission of state symbols.

It was often difficult to decide whether the symbol for lead contained an upper case or lower case 'p'. Candidates should use the Periodic Table to determine how to write symbols.

(b) Many candidates gave tests for other gases including glowing and burning splints, litmus paper and lime water.

Those who knew that potassium manganate(VII) was the correct reagent often spelt manganate incorrectly or used the wrong oxidation state or omitted the oxidation state entirely. The wrong oxidation state of potassium was occasionally seen e.g., as in potassium(VII) manganate.

(c) The majority of candidates were correct in using 2CoO and $4NO_2$. However $8H_2O$ was only seen extremely rarely. $4H_2O$ was far more common.

(d) (i) Only a minority of candidates were aware of the technique of heating to constant mass.

Despite the instruction 'no other substance is required' many candidates suggesting using a substance used to test for the presence of water.

(ii) Calculations are generally well done. The first three answers were often correct; the fourth answer less so.

Question 6

(a) (i) This was answered reasonably well. Common incorrect answers seen were: lime or CaO; limewater; calcium silicate/slag; coke; cryolite; hot air; water.

(ii) This was answered well. Common incorrect answers included water; calcium silicate/slag; iron ore/iron oxide.

(iii) Only the minority of candidates could correctly name the impurity. Common errors included silicon oxide or silicon(II) oxide. Other substances seen included calcium silicate/slag.

(iv) This was answered reasonably well. The most common error was to give air as well as or instead of oxygen. The blast furnace reaction between carbon dioxide and coke was also seen occasionally.

(v) Carbon dioxide was seen very often. Nitrogen and argon were much less common. Toxic gases such as carbon monoxide, sulfur dioxide and nitrogen dioxide were seen quite often.

(b) (i) Most candidates referred to the high temperature but omitted any reference to the boiling temperature of zinc.

(ii) This was answered very well. Sublimation was seen occasionally.

(c) (i) This was answered quite well. Electroplating, electrolysis and sacrificial protection were common wrong answers.

(ii) Most candidates commented that zinc is more reactive than iron.

Comments that did not gain credit included:

- zinc rusts (it does not)
- zinc reacts (without mentioning what it reacts with)
- zinc or zinc oxide forms a barrier (does not apply if there is a scratch).

(d) (i) There were many incorrect spellings of amphoteric. Less common were mentions of acidic, basic or neutral oxides.

(ii) This was answered reasonably well. Some answers gave unnecessary brackets i.e., $Na_2(ZnO_2)$ Common errors were $NaZnO_2$ and Na_2ZnO. Many formulae showed charges.

(iii) This was answered quite well. Zinc sulfide was the most common error.

Question 7

(a) (i) There were many correct answers which showed detailed and correct working out.

Some candidates correctly obtained a mole ratio of atoms as 1: 2.5 and then incorrectly approximated this to give formulae of CH_3 or CH_2. Occasional use of atomic numbers or relative molecular mass instead of relative atomic mass was seen.

(ii) Some calculated that 70 ÷ 14 = 5 then went on to give an answer of $5CH_2$ or $(CH_2)_5$ instead of C_5H_{10}.

(b) Many of the monomers shown contained carbon atoms with 5 bonds each. This was because candidates drew a repeat unit with a double bond but still containing extension bonds. The CH_3 groups were often not given as displayed.

Candidates should be aware that straight chain alkenes with four carbon atoms must contain a number in their name i.e., but-2-ene (as in this case) or but-1-ene. There is no alkene whose name is butene.

(c) This was answered very well. C_8H_{18} and $2C_4H_8$ were occasionally seen.

(d) (i) This was answered poorly. Isomers and isotopes were the most common incorrect answers. Homologous series was seen occasionally.

(ii) This was answered very well. Methanoic acid and ethanol were seen occasionally.

(iii) The O-H bond was frequently missing from the displayed formula.

Many carboxylic acids were named. Ethanoic acid and butanoic acid were the most common errors. The displayed formula and the name often were different substances.

CHEMISTRY

Paper 0620/42
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 sensible guesses rather than leaving an answer blank.
- If, for example, a single answer is asked for, two (or more) answers should not be given as incorrect statements may contradict correct answers. There were frequent incidences of candidates giving more than one answer where only one was required and thus not gaining credit. One example was **Question 4(f)(iii)** where the correct response of 'universal indicator' was often contradicted by a second named indicator such as 'methyl orange'.
- Handwriting was sometimes a problem and candidates need to make sure that an 'a' is distinct from an 'e' as it was often difficult to determine between 'propene' or 'propane' for example, as in **Question 1(a)(iii)**; similarly for 'propanoic/propenoic' acid in **Question 4(c)**.

General comments

The overall standard was higher than in June 2023 which was the first June examination following a syllabus change. It was noticeable in June 2024 that there was less unfamiliarity with the newer content of the new syllabus.

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

When changing an answer, candidates should rewrite the whole word rather than attempting to overwrite a single letter.

Comments on specific questions

Question 1

(a) This question, requiring choices from the 10 gases given in the question, proved to be challenging for some candidates. Most candidates could correctly name helium in **(iv)** and carbon monoxide in **(v)**, but the degree of accuracy was less on the other parts with very few knowing nitrogen dioxide in **(ii)** where most opted, incorrectly, for sulfur dioxide.

(b) Many candidates were able to identify the correct products but found balancing the equation challenging. Common errors were: extra products such as water and oxygen and species not derived from the reactants; NO as a product rather than N_2; NO as a reactant rather than NO_2; CO as a product; two individual equations given rather than one ($2CO + O_2 \rightarrow 2CO_2$ and $2NO_2 \rightarrow N_2 + 2O_2$).

Question 2

(a) (i) Nearly all candidates were able to describe electron loss when atoms form positive ions.

(ii) Most candidates knew potassium had the greatest tendency to form positive ions.

(iii) Although a significant number of candidates thought silver was not likely to have catalytic properties, most candidates correctly opted for either of the two non-transitional metals in the list.

(iv) Silver proved to be a popular incorrect answer, but most candidates could state iron as the major component of stainless steel.

(b) This question tested knowledge of displacement reactions and better performing candidates did well. Most candidates knew that magnesium would displace iron to form a colourless solution. White was the incorrect colour of choice amongst candidates who performed well.

The reverse argument applied to the second row where no displacement reaction took place so the initial blue colour did not change during the reaction.

(c) (i)(ii) Most candidates knew the products were hydrogen and strontium hydroxide respectively, although some candidates opted for strontium oxide.

(iii) Only a few candidates were aware of the behaviour of magnesium in steam to form magnesium oxide. The most common answers were calcium and calcium hydroxide.

(d) This difficult question differentiated very well. The better performing candidates secured full credit whereas some could only give the formula of either salt formed, $FeCl_2$ or $FeCl_3$, often completely omitting water as a product despite it being given in the question.

Question 3

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

(b) Relatively few candidates were familiar with learning objective 5.1.4 of the syllabus which is 'State that the transfer of thermal energy during a reaction is called the enthalpy change, ΔH, …' and thus the simple answer 'enthalpy change' was not seen too frequently. Others correctly stated 'the transfer of thermal energy during a reaction'. The most common error was 'energy change'.

(c) The temperature, pressure and identity of the catalyst were well known.

(d) As the conditions given were temperature and pressure, most candidates simply, and correctly, suggested increasing the temperature and increasing the pressure would increase the rate of reaction. Candidates who performed less well suggested adding a catalyst without recognising that the reaction was already catalysed. Other acceptable answers were 'increase the concentration (of reactants)' or 'use a more finely divided catalyst'. Other candidates misinterpreted the requirement of the question and explained how to increase the yield by shifting the equilibrium to the right-hand side.

(e) Most candidates seemed well practiced in how to carry out this type of calculation and were able to follow the steps given. Any errors were usually made in the second step as a result of subtracting 90 from the first step. The third step was still usually correctly done and 'error carried forward' was often awarded.

(f) (i)(ii) Most candidates realised that H_2O was the missing formula from the equation and could name NH_4Cl as 'ammonium chloride'.

(iii) In general, candidates performed well with this difficult unstructured calculation. Most could determine the number of moles of CaO as 0.0200. Candidates who performed well overall were able to apply stoichiometry and determined the number of moles of NH_3 as 0.0400. Having got this, many incorrectly multiplied by 24 to give an answer in dm^3 rather than multiplication by 24000 to give the correct answer in cm^3.

Question 4

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

(b) The name of the ester was known by most candidates. The most common error was the misspelling of 'propanoate' as 'propanote or 'propenoate'.

(c) The correct name, 'propanoic acid', was known by most candidates, but many of these candidates drew the displayed formula incorrectly as a result of omitting the O–H bond.

(d) The name and structural formula of methanol were well known.

(e) Most candidates were able to predict the effect of changing the conditions.

(f) (i) Most candidates performed well. Common errors were:
- giving the initial pH as 'about 7' (it is exactly 7)
- giving the pH at equilibrium as 'below 7' (this term includes pH 1 and pH 2, which is too low for typical carboxylic acids).

Weaker responses tended to use phrases such as 'neutral' or 'weak acid' rather than use numbers.

(ii) Most candidates correctly identified the H^+ ion as the cause of change in acidity.

(iii) Most candidates named universal indicator as an indicator which could be used to follow changes in pH. Quite often candidates named additional, incorrect indicators and consequently contradicted a previously correct answer.

Question 5

(a) (i) Most candidates successfully completed Table 5.1.

(ii) Many candidates applied learning objective 2.3.3 of the syllabus to this question which is 'State that isotopes of the same element have the same chemical properties because they have the same number of electrons and therefore the same electronic configuration'.

Thus, answers such as 'same number of electrons' or 'same electronic configuration' gained credit. Also awarded credit was the commonly seen phrase 'same number of outer shell electrons' which is intended to explain 'similarities in the chemical properties of elements in the same group of the Periodic Table'.

(iii) Only the better performing candidates tended to correctly give 34 g as the mass of 6.02×10^{23} atoms of ^{34}S. Most attempted to multiply 6.02×10^{23} by 34.

(iv) Only the better performing candidates recognised that the amount of substance which contains 6.02×10^{23} of atoms is **one** mole. 'Mole' or 'mol' was given credit but 'mole**s**' was not.

(v) Many candidates were able to calculate the relative atomic mass and nearly all calculated the isotopic mass x abundance. Most of these divided their first sum by 100 to produce 32.1 as the final answer.

(b) (i) Many candidates were able to give a fully correct dot-and-cross diagram. Candidates who performed less well were only able to give the correct charges. Common errors were using all dots or all crosses or showing magnesium's outer two electrons in two places on the diagram.

(ii) Most of the better performing candidates secured credit for describing ionic bonding as 'strong', frequently using the often seen phrase 'strong electrostatic forces of attraction between (oppositely charged) ions'. Weaker responses often contradicted themselves with incorrect terms such as 'intermolecular forces' for 'electrostatic forces of attraction' or 'atoms' for 'ions'.

(iii) Many candidates wrote about 'mobile electrons' rather than 'mobile ions', or ions being 'free' rather than 'ions being mobile'.

(c) (i)(ii) Only the better performing candidates recognised the acid must have the formula H_2SO_3 to form a salt with the formula Na_2SO_3. H_2SO_4 was a common error. Fewer candidates recognised SO_3^{2-} as the anion in Na_2SO_3.

(d) (i) This was a challenging question as it required candidates to realise that the Roman numeral (VII) informs that mangan**ese** has an oxidation state of +7. The most frequent near miss was to state that mangan**ate** has an oxidation state of 7.

(ii) Most candidates knew the colour change when potassium manganate(VII) oxidised something is from purple to colourless.

Question 6

(a) (i)(ii) The name 'photosynthesis' was well known as was the symbol equation.

(iii) Learning objective 10.3.5 of the syllabus describes photosynthesis as the 'reaction between carbon dioxide and water to produce glucose and oxygen in the presence of chlorophyll and using energy from light'. Therefore, the expected essential conditions were 'chlorophyll' ('chloroplasts' was allowed) and 'light'. Carbon dioxide and water are, as the question stated, reactants.

(b) (i)(ii) The name 'fermentation' was almost universally known as was carbon dioxide as the other product.

(c) (i) The temperature, pressure and identity of the type of catalyst (i.e. acid) were well known.

(ii) Although candidates generally knew about addition reactions, less than half could quote from learning objective 11.5.5 of the syllabus and state 'that in an addition reaction only one product is formed'.

(iii) The dot-and-cross diagram of ethanol was drawn well by most candidates with each covalent bond being represented by a dot and cross. Although not necessary, some candidates felt the need to introduce a third symbol for electrons belonging to hydrogen atoms. Candidates who used a pair of the same symbols for a covalent bond did not receive full credit. Weaker responses did not show the non-bonding electrons on the oxygen atom.

CHEMISTRY

Paper 0620/43

Theory (Extended)

Key messages

- When a question asks for an explanation for a higher melting point of one compound compared to another in terms of structure and bonding, candidates should ensure that ‘structure’, for example giant covalent, forms part of their answer and that their answer is comparative.
- Candidates should be aware when explaining why a substance conducts electricity that the word ‘free’ is not equivalent to mobile, and should refrain from using it as it will not receive credit.
- When a question asks for a displayed formula then the molecule should be drawn showing all the bonds including the O–H bond.
- When naming molecules with higher numbers of carbon atoms, it is important that the name indicates the position of the functional group. Butene is insufficient as the correct name for but-1-ene and propanol is insufficient as the correct name for propan-1-ol.

Comments on specific questions

Question 1

(a) The Haber process was known by many candidates, although a wide variety of spelling was used. The Contact process and nitrogen fixation were occasionally seen.

(b) Electrolysis was well known.

(c) This was answered quite well.

(d) Candidates found this the most difficult part of **Question 1**. The most popular incorrect answer was fermentation, although oxidation, hydrolysis, hydrogenation and cracking were also regularly seen.

(e) Chromatography was generally well known by candidates.

(f) This was answered quite well. Distillation was sometimes seen instead of fractional distillation.

(g) This was challenging to many candidates. Neutralisation was the most common incorrect answer.

Question 2

Candidates usually performed quite well on this question. The majority were able to give the correct numbers of electrons and neutrons for the copper atom. However, many were unable to link the charge on the chloride ion with the correct number of electrons and the number was often given as 16 or 17 rather than 18. The missing symbol was regularly given as Cu, presumably because the element was identified by relative atomic mass rather than the atomic number. Candidates are advised to follow the format given in the question and write the relative atomic mass to the top left and the atomic number to the bottom left of the symbol. The relative atomic mass was regularly given as 65 rather than 64.

Question 3

(a) (i) Those candidates who mentioned electrons often omitted to refer to their movement. ‘Free’ or ‘delocalised’ was seen often in place of ‘mobile’ and neither term gained credit. Electrons were often described as ‘carrying charge’. This also gained no credit. Some poorly performing candidates referred only to graphite as having a high melting or boiling point.

(ii) This was answered very well. A single covalent bond was drawn occasionally. Some candidates used only one symbol to represent the electrons from both atoms and did not gain full credit as the resultant is not a ‘dot and cross’ diagram. It is good practice to draw non-bonding electrons in pairs as it is easier to check that atoms have a complete octet and this helps reduce the likelihood of miscounting.

(iii) Many candidates gave the correct physical state as liquid. However, answers describing a change of state, for example melting, were also common.

Subsequent explanations were often incomplete with many describing the temperature of –195 °C as either being above melting point or below boiling point but not both, as required. Many candidates seemed to have difficulties in understanding negative numbers and believed –195 °C was a lower temperature than –199 °C. Describing –195 °C as being *between* the two temperatures or *between* melting and boiling points was a successful way of avoiding many of the potential errors with negative numbers. In this part of the question, candidates were required to use the data to explain their answer but many simply stated it. For example, statements such as ‘at –199 °C it has melted and at –191 °C it has boiled so at –195 °C it is a liquid’ were insufficient to gain credit.

(iv) The question asked for an explanation of the much higher melting point of graphite compared to carbon monoxide in terms of both structure and bonding. The three key marking points were:

- graphite has a giant covalent structure
- carbon monoxide has attraction between molecules
- attraction between atoms in graphite is stronger than attraction between molecules in carbon monoxide.

Whilst many knew that the bonding in graphite was covalent, few attempted to also describe the required giant structure. Many candidates wrote non-comparatively about graphite and made no reference to carbon monoxide. When two substances are being compared it is also important that candidates clearly identify the substance they are describing. Use of the non-specific ‘it’ should be avoided.

The most common errors seen were: covalent bonding in graphite contradicted by references to intermolecular forces between atoms or strong intermolecular forces; ionic bonding in graphite described; breaking of covalent bonds during melting in carbon monoxide; bonds in graphite are harder to break rather than bonds are stronger or require more energy to break; comparison of strength of structure rather than strength of bonding.

(b) The formula of chlorine was often represented as either Cl, Cl^- or $2Cl$. The most common error seen was an incorrect formula of potassium chloride, frequently given as KCl_2, K_2Cl or with charges. The equation was often unbalanced. Candidates should be aware that if a symbol for an element has two letters, as is the case with Cl, the second letter must be clearly seen to be lower case.

(c) (i) Candidates should make sure that they are well prepared for questions of the type ‘state what is meant by the term...’ as these are easy recall marks gained for definitions given in the syllabus.

Common errors included: describing ‘separation of ions’ (a physical change) rather than ‘separation into elements’; omitting that the compound to be decomposed must be ionic; omitting that the compound must be molten or aqueous.

(ii) Candidates found this question very challenging. The majority gave the ionic half-equation for the production of oxygen from oxide ions that would occur in a molten electrolyte containing oxide ions. Very few identified that hydroxide ions lose electrons at the anode in the electrolysis of dilute aqueous potassium chloride.

Question 4

(a) Well-prepared candidates who had learnt the conditions of a reversible reaction at equilibrium given in the syllabus performed well on this question. The most common errors were: describing the rates as constant rather than equal; describing the concentrations as equal or the same rather than no longer changing, although 'concentrations remain the same' would have been acceptable.

(b) Candidates found this to be the most demanding question on the paper. An explanation of the darker brown colour in terms of particles was asked for. Successful answers had to refer to nitrogen dioxide particles without saying more nitrogen dioxide was formed or suggesting that the equilibrium shifted. Many candidates wrote either about more nitrogen dioxide in a smaller volume but omitted 'particles' or 'molecules' from their answer or wrote generally about more particles in a smaller volume without specifying nitrogen dioxide particles.

(c) Many candidates did not understand that if a temperature increase produces an increase in yield of the forward reaction, then that reaction must be endothermic. Many wrote only that the reaction had shifted in the forward direction or that the rate of the reaction had increased. Exothermic was another common incorrect answer.

(d) (i) This question was well answered by most, but candidates should be reminded that if the question requires them to choose only from the specific words given to them, use of alternative ones may lose credit.

(ii) Oxidation numbers appeared to be poorly understood. Many candidates seemed unfamiliar with the statements given in section **6.4.9** of the syllabus on oxidation numbers in elements and compounds that help in answering these deduction questions. Weaker responses often gave the much larger relative atomic and molecular masses rather than oxidation numbers. Oxidation numbers written as ionic charges did not gain credit. The oxidation number of sulfur in SO_3 was found to be particularly difficult and a wide variety of incorrect answers was seen. A common near-miss error was the omission of the + sign from 6 (+6).

Question 5

(a) (i) A large number of candidates named solutions containing neither barium nor sulfate ions. Barium compounds suggested were often insoluble. Weaker candidates often named barium and sulfur. Candidates should be reminded that if an oxidation number of a transition metal within a compound is given then it must be correct.

(ii) Some candidates were clearly familiar with the method of obtaining an insoluble salt and were able to give the three processes of filtration, washing and drying of the precipitate clearly and concisely. Many others were confused and described a method of obtaining the soluble salt by crystallisation. Omission of washing or drying steps after filtration were common errors. Very weak candidates often wrote about use of electrolysis or fractional distillation to obtain the salt.

(iii) Many candidates were poorly prepared and obviously struggled with giving an ionic equation for precipitation formation. Such equations will always have two reactant ions and one product compound. The sequence of state symbols will always be (aq) + (aq) → (s).

Candidates might be advised to identify the solid product and 'split' this up into its constituent ions as these will be the reactants.

Non-ionic equations were common. Despite the formula of barium sulfate being given in the question it was frequently incorrect. Very weak responses often gave Ba and S as reactants. State symbols were often not attempted.

(b) The majority of candidates were able to gain partial credit by naming sulfuric acid but many found naming the second compound more challenging. Very common incorrect answers were copper and copper(II).

(c) (i) Candidates should be encouraged to learn the tests for gases as described in the syllabus. Many candidates appeared unfamiliar with the test for oxygen. It was often confused with the test for hydrogen using a lighted splint. Use of a 'blown out splint' will not gain credit unless it is additionally described as 'glowing'. The glowing splint should not be described as 'relights with a pop' as this is also confusion with the test for hydrogen. Very weak responses described only the heating of the original compound to produce bubbles or even the testing of the evolved gas by breathing it.

(ii) Very few candidates gained full credit on this question as most seemed unaware that the **2** at the beginning of **2**$Cu(NO_3)_2$•$3H_2O$ multiplies everything in the formula that follows it by **2**. In the products, **2**CuO was commonly seen but **4**NO_2 was less common. Unfortunately, **3**H_2O was usually given and **6**H_2O was only seen extremely rarely. Candidates often had multiple attempts to balance this equation with repeated crossings out. The end result was often almost illegible if the final equation had not been clearly written out again.

(d) (i) This was quite well answered, although weaker answers focussing on increasing accuracy or reliability were common.

(ii) Candidates were most commonly able to determine the mass of water given off. Many calculated the first three values correctly but were unable to determine the value of **x** from the numbers of moles of water and of zinc sulfate.

Question 6

(a) (i) This question was answered quite well. Bauxite, iron oxide and limestone were the most common incorrect answers seen.

(ii) Oxygen was commonly seen instead of, or in addition to, air. It did not receive credit in either case as pure oxygen is not used in the blast furnace. Water was another common incorrect answer.

(iii) This question was well answered. Limestone was the only commonly seen incorrect answer.

(iv) Many candidates had no understanding of the role played by limestone in the blast furnace and received no credit. Common incorrect answers were: catalyst; reduces iron(III) oxide; heats the furnace; lowers the operating temperature (confusing limestone with the role of cryolite in the extraction of aluminium). Some knew that limestone had a role in removing impurities but were not able to offer creditworthy detail.

Many candidates did demonstrate good knowledge of the chemical reactions involving limestone. 'Limestone decomposes' was insufficient for 'thermal decomposition', as per the syllabus. Many were able to state that slag or calcium silicate was formed but far fewer were able to correctly describe the reaction between calcium oxide and the impurity silicon(IV) oxide that produces the slag. Some candidates achieved all three marks by giving two equations.

(b) (i) This question was well done. The majority of candidates knew that Group I metals have low density low melting points whereas transition metals do not.

(ii) This was well answered and the chemical properties of transition metals seemed to be widely known.

(iii) Few candidates knew that forming positive ions or forming basic oxides were properties of both metals.

(iv) Few candidates knew that neither metal would form acidic oxides nor form negative ions.

(c) (i) The question required a comparative explanation of sacrificial protection in terms of electrons. The majority of candidates knew that magnesium was more reactive than iron or steel but did not explain how this protects iron in terms of losing electrons in preference to it. Commonly seen incorrect answers were: magnesium has more electrons or less electrons than iron; magnesium is more likely to gain electrons than iron; magnesium rusts instead of iron.

(ii) This was well answered. Some candidates unfortunately chose a less commonly encountered metal than copper, silver or gold, for example titanium, which was more reactive than iron. Iron itself was commonly suggested but received no credit.

Question 7

(a) (i) Many candidates seemed well practiced in calculation of empirical formulae from percentage composition and there were some excellent answers to this question in which all steps of the working were clearly shown. However, some candidates clearly had no idea how to proceed. Common errors included:

- dividing both percentages by 16.67 instead of using the A_r of each element, giving a ratio of 5 : 1 and a formula of C_5H
- incorrectly rounding the number of moles of hydrogen atoms from 2.4 to either 2 or 3, giving a formula of CH_2 or CH_3
- multiplying the ratio of 1 : 2.4 by two to give 2 : 4.8 and then rounding this to 1 : 2:5, giving a formula of C_2H_5
- dividing the percentages by the relative atomic masses instead of the A_r of each element.

(ii) Many gave 29 as the molecular formula due to candidates not multiplying the empirical formula by a factor of two. Others gave formulae with large numbers of atoms. $2C_2H_5$ was commonly seen.

(b) (i) Despite being designed as an easy recall question, many candidates were unable to give the functional group of the alkenes. ‘Contains a double bond‘ or ‘contains a double carbon bond’ are both insufficient as they lack the idea of the double bond being between two carbon atoms. The general formula of alkenes was commonly seen, as were the molecular formulae of ethene and propene.

(ii) Most candidates found this question very challenging and few achieved all three marking points. Candidates were told in the question stem that the polymer was formed from an alkene. Despite this, only a minority drew the displayed formula of an alkene. Candidates should be reminded that alkene monomers that form addition polymers always contain double bonds between two of the carbon atoms. The monomer is a discrete molecule without continuation bonds. Many candidates merely redrew a section of the polymer given in the question, complete with continuation bonds.

Candidates should also be reminded that if a question asks for a displayed formula, then **all** of the bonds present must be shown and it is expected that alkyl groups will be drawn in full.

Naming of the monomer proved to be similarly difficult. Those candidates who had identified that the monomer must contain four carbons usually incorrectly named it butene. It is worth pointing out that organic molecules should be named according to IUPAC nomenclature, in this case but-1-ene, and not 1-butene or butene.

(c) (i) Candidates found this very difficult. Ethene was often not given as one of the products and the ratio given in the question was ignored. Many did gain one mark for $C_2H_4 + C_{10}H_{22}$. The most commonly seen incorrect answer was $C_4H_8 + C_8H_{18}$ which, although balanced, does not contain ethene. Weaker candidates often wrote $C_{12} + H_{26}$.

(d) (i) The general formula of the alcohols was reasonably well known but candidates need to be careful in their use of subscript as $C_nH_{2n+}1OH$ did not receive credit. A common incorrect answer was $C_nH_{2n}O$.

(ii) The majority of candidates were able to make a recognisable attempt at drawing the structure of propan-1-ol but many did not display the O–H bond and so did not gain credit. Few attempted to draw propan-2-ol.

Naming again proved challenging as propanol was usually given. Candidates should use the IUPAC names of propan-1-ol or propan-2-ol rather than 1-propanol/ 2-propanol or older names such as n-propyl alcohol.

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Paper 0620/51
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.
- Readings recorded from a given item of apparatus should all be recorded to the same resolution (the same number of decimal places).
- 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 on page 49 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, 'Identify the gas given off', 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).
- 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.
- When a question asks for the name of a chemical, a correct formula is acceptable. However, if a candidate answers with an incorrect formula, then credit will not be awarded. When a question asks candidates to identify a substance the name or formula is acceptable. However, incorrect names of formulae will not be accepted.

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 paper was generally well answered, with very few blank spaces.

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 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 candidates were able to complete correctly Table 1.1 and recorded a temperature increase in Experiment 1 that was comparable to the supervisor's results. The most common errors included not recording temperature and temperature changes to a consistent number of decimal places and to not have the volume of water as zero in Experiment 1.

(b) (i) Almost all candidates correctly identified the experiment having the smallest temperature change. This should have been Experiment 5.

(ii) Most candidates were able to correctly explain that Experiment 5 had the smallest temperature change because the volume of water was the largest. The very best responses went on to explain that in all 5 experiments the heat energy given out was the same, but it was used to increase the temperature of increasingly large volumes of liquid.

(c) While many fully correct graphs were seen, there were a number of common errors, these were:

- inappropriate graph scales including non-linear scales. Candidates who chose awkward scales, such as each a large grid square being equivalent to 3 °C, often plotted points incorrectly. Points plotted in non-linear regions could not be awarded credit. Some candidates did not spot that 0 °C was give on the *y*-axis.

- The most common error was to draw a straight line of best fit through the points even when the plotted points lay on a curve. If the best-fit straight line has the points at either end of the line on one side and the points nearer the middle of the line on the other side then that should suggest that the line should be a curve.

(d) Most candidates indicated on the graph from where they were taking their reading and correctly recorded the expected temperature increase. The recommended method is to draw a vertical line from the required position on the *x*-axis (7.5 cm^3) up to the graph line and then horizontally across to the *y*-axis in order to make the required reading. Common errors were to work from 7 cm^3 rather than 7.5 cm^3 or to draw construction lines on the graph which were some way from the vertical or horizontal.

(e) This calculation was well answered by many candidates. The most common error in the numerical value was to truncate the number. The units of the average rate of temperature increase are determined by dividing the unit for temperature change (°C) by the unit for time (s), giving °C / s.

(f) (i) Better responses correctly stated that cotton wool was an insulator and that this would mean there would be less heat loss from the boiling tube and so the temperature change measured would be more accurate. A common error was to state that the cotton wool would keep the temperature constant, as the temperature change is the dependent variable in this investigation, keeping it constant would defeat the purpose of the investigation. Some candidates confused the use of cotton wool with investigations into the rate of reaction by following the mass of gas lost.

(ii) Most candidates correctly stated that the volumetric pipette would only measure a fixed volume. Better answers went on to explain that in no experiment was the volume of water 25.0 cm^3. A common error was to confuse a volumetric pipette with a dropping (Pasteur) pipette or to think that the slow addition of water from the pipette would be a problem; as the water is added to the acid before the reaction starts, slow addition is not a problem.

(iii) Many candidates suggested using a burette to improve the accuracy but did not say what the burette would be used for or in place of, and so did not gain credit. One of the more common errors was to use a digital thermometer. There is no reason why a digital thermometer should be more accurate than a liquid in glass thermometer; a digital thermometer depends on electrical components and as their capacitance or resistance can change over time, the temperatures shown can drift from the true value. A digital display that can read to 0.1 °C does not necessarily mean greater accuracy.

(g) Most candidates realised that a shorter length of magnesium ribbon would result in less heat energy being given out to the solution and so a smaller temperature change. It was a relatively common error to have the sketch line joining the plotted line at one or both ends. In reality, if less energy is given out then the temperature change will be lower for all volumes of water added.

Question 2

(a) Some candidates gave full and detailed observations. The solid changed colour to green upon heating. The solid was frequently referred to as a precipitate. A precipitate is a solid formed from the reaction between two solutions; if when two solutions are mixed the product becomes cloudy and opaque then a precipitate has been formed. This is incorrect usage of the term. Other possible observations included the melting of the solid or condensation forming near the mouth of the tube.

(b) (i) Many candidates correctly suggested that a green precipitate formed and that upon addition of excess, the precipitate would dissolve. Some candidates recorded the incorrect colour such as blue or white. A significant number of candidates did not use the term ‘precipitate’ when describing the cloudiness or opaqueness of the mixtures. Some candidates did not add sufficient sodium hydroxide to enable their precipitate to dissolve. Some candidates recorded additional incorrect observations, such as effervescence. Additional incorrect observations were rejected.

(ii) This question was well answered by most candidates. Some candidates reported impossible gas test results given that the gas produced was ammonia.

(iii) Most candidates were able to identify the gas as ammonia. Some candidates did not gain credit in **(b)(ii)** but still managed to gain credit for correct identification of ammonia. To identify the gas correctly, damp red litmus should have been used and as a result, should have been given in the answer to **(b)(ii)**.

(c) This was a more demanding test. Candidates often missed the observation of effervescence or did not quote an observation. The statement ‘a gas is formed’ is not an observation since the gas is colourless and so invisible. The relevant observation would be effervescence or fizzing or bubbles (of a gas). The colour of the precipitate was often stated to be blue or white.

(d) (i) Most candidates recognised that the colour of the potassium manganate(VII) did not change but they did not record their observation correctly. Candidates were expected to observe that the colour of the solution of E changed to pink/purple. A common response was to state that there was no change which would imply the colour of E did not change when the potassium manganate (VII) was added.

(ii) A large proportion of candidates managed to gain credit for this question even without gaining credit for **2(d)(i)** as they realised that they were testing for presence of the anion, sulfite. Candidates were successful in recognising that **E** remaining purple would indicate that sulfite was not present. A small number of candidates stated that ‘no sulfur dioxide was present’. This was ignored as we were not testing for sulfur dioxide gas.

(e) This was well answered by most candidates. The most common mistakes were recording of the incorrect colour of precipitate or not using the term precipitate.

(f) Some candidates did not attempt to identify three ions and only attempted one or two. A small number of candidates gave more than three ions which meant they could not gain full credit. Candidates who chose to give the formulae of the ions rather than the names sometimes did not gain credit by writing incorrect formulae.

Question 3

Some excellent and succinct descriptions of how to obtain pure samples of each component of the mixture were seen. As this was a qualitative task there was no need to control masses or volumes.

The simplest route through the separation task was:
- filter the mixture to obtain ethanol as the filtrate
- add the residue from the filtration to water and stir to dissolve the sodium chloride
- filter the mixture to obtain zinc carbonate as the residue and aqueous sodium chloride as the filtrate
- wash and dry the zinc carbonate
- warm the filtrate to evaporate all of the water and leave behind solid sodium chloride.

Other processes, such as fractional distillation to obtain ethanol after the addition of water would also work and could gain full credit.

Some of the more common errors were:
- adding ethanol to the mixture and then obtaining ethanol from the mixture. This action meant the marking point for obtaining a sample of ethanol could not be awarded.
- not washing and drying the zinc carbonate after filtration.
- not adding water to the mixture, meaning it was not possible to separate the zinc carbonate from the sodium chloride. It is possible that candidates who did this had not read the question carefully and had assumed the mixture already contained water.
- not trying to separate a mixture at all, instead carrying out tests on individual substances. This approach did not answer the question asked and so could not receive any credit.

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Paper 0620/52
Practical Test

Key messages

- The Confidential Instructions state that the supervisor must do the experiments in **Question 1** and **Question 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. Substances used should be of good quality. It was evident from results recorded that, on occasion, some substances used were contaminated or partially decomposed.

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

- When a question asks candidates to identify a substance the name or formula is acceptable. However, incorrect names or formulae will not be accepted (for example, 'chlorine' is not an acceptable alternative for 'chloride'). General terms such as 'salt', 'acid', 'impurity' or 'residue' will **not** gain credit if the identity has been asked for.

- 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.

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

General comments

The vast majority of candidates successfully attempted all of the questions. The paper discriminated successfully between candidates of different abilities but was accessible to all. The paper was generally well answered, with very few unanswered questions.

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

Comments on specific questions

Question 1

(a) The vast majority of candidates were able complete correctly Table 1.1. At IGCSE level, all burette readings are accepted to 1 decimal place or all readings to the nearest 0.05, but not a mixture of the two.

The titre in Experiment 2 should have been approximately twice the titre in Experiment 1. The majority of candidates gained titres for Experiments 1 and 2 that were in line with those recorded by the supervisor.

(b) Most candidates gave an appropriate colour change for thymolphthalein indicator in Experiment 3.

(c) The majority of candidates correctly stated that the flask was swirled to mix the solutions or to ensure an even distribution of each solution.

(d) In Experiments 1 and 2, the end-point was the formation of a white precipitate rather than the more normal indicator colour change seen in a titration. Some excellent answers explained that the formation of the white precipitate would be difficult to see against a white tile but that the black background provided a contrast making the formation of the precipitate easier to see. To gain credit, answers had to refer to the formation of the precipitate (or cloudiness/mistiness) being easier to see. Answers that just referred to the colour change did not gain credit.

(e) (i) The need to clean the measuring cylinder due to two experiments using different solutions with different concentrations was well understood.

(ii) Most candidates understood that because the same solution (solution **G**) was used in both Experiments, there was no need to rinse the measuring cylinder. Some candidates referred to an incorrect reagent being in the measuring cylinder, such as aqueous aluminium chloride, and so did not gain credit.

(f) Some fully correct and clearly explained answers were seen. Solution **G** should have required a larger volume of aqueous aluminium chloride to reach the end-point. This means that solution **G** must have a higher concentration that solution **F**. The ratio of the titres in Experiments 1 and 2 should have shown that the volume of aluminium chloride required in Experiment 2 was about twice that needed in Experiment 1 and so **G** was twice the concentration of **F**.

Some candidates, although spotting the 1 : 2 ratio, thought that solution **F** must be more concentrated because it reacted more quickly or that the titres were the volumes of **F** and **G** rather than the volumes of aqueous aluminium chloride.

(g) This calculation was well answered. A small minority of candidates used the second burette reading in Experiment 1 to calculate the expected volume rather than the titre.

(h) Some excellent answers were seen with candidates explaining that the volume of aqueous aluminium chloride was unknown at the start of each experiment and because volumetric pipettes can only be used to measure a fixed volume they could not be used to measure the unknown volume 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 more than $5\,cm^3$. There also seemed to be some confusion with a question on a previous examination paper in which the reaction occurring as the reactant was added slowly from a pipette was a problem. However, in this titration we are interested in the volume required; it is not based on the rate of the reaction and so the addition being slow is not an issue.

Question 2

(a) (i) The confidential instruction required candidates to have 0.5 g of barium carbonate in a boiling tube. This mass of barium carbonate will react completely with 5 cm^3 of 1 mol / dm^3 hydrochloric acid. With the quantities specified the dilute hydrochloric acid would have been in a 100% excess and so all of the solid barium carbonate should have reacted to form a colourless solution.

Since the question told candidates to ‘Test any gas produced’ candidates were expected to describe the test and the positive result produced; there is no need to list negative test results. The expected observations were that there was effervescence and the solid disappeared forming a colourless solution, the gas formed should have turned limewater milky.

(ii) The majority of candidates correctly identified the gas produced as carbon dioxide, although many other gases were suggested by a minority of candidates.

(b) The expected flame test colour was light green. Where centres submitted completed supervisor’s results, other colours seen as a result of contaminated samples could be allowed; this cannot be done if the supervisor does not fully complete their copy of the paper.

(c) (i) Addition of purple aqueous potassium manganate(VII) should have resulted in the portion of solution **J** becoming purple or pink. There would also have been a precipitate of barium sulfate formed; the precipitate formation was ignored and credit was awarded for the colour.

(ii) This question asked candidates to use the result of the test in **(c)(i)** to make a conclusion. A minority of candidates did not confine themselves to **(c)(i)** and used other test results to answer the question. As the addition of aqueous potassium manganate(VII) is the test for sulfite ions, candidates should have concluded that no sulfite ions were present.

(d) The majority of candidates correctly stated that a white precipitate formed.

(e) The majority of candidates correctly stated that no reaction occurred. Some candidates reported a white precipitate which suggests they did not use the solutions specified in the question.

(f) Many candidates identified barium carbonate correctly. Where the flame test colour in **(b)** was yellow or orange-red and error carried forward could be applied and credit given for identifying sodium or calcium respectively. It should be noted that ‘orange’ is an acceptable alternative colour for sodium ions in a flame test; the colour in the notes for qualitative analysis for calcium ions is orange-red.

(g) The addition of aqueous sodium hydroxide to solid **I** would have resulted in the formation of ammonia gas. This should have turned damp red litmus paper blue but should not have changed the colour of damp blue litmus paper. The majority of candidates correctly stated the colours seen. A minority gave results, such as bleaching, which was impossible given the reagents used.

(h) (i) Most candidates correctly reported the formation of a white precipitate.

(ii) The addition of ammonia should have caused the precipitate to fully dissolve on shaking. However, if a large amount of aqueous silver nitrate had been added rather than just a few drops then some of the precipitate may have remained; it is important candidates follow the instructions carefully. The halide ion test needs only two or three drops of aqueous silver nitrate and the sulfate test only two or three drops of aqueous barium nitrate.

(i) Most candidates recorded a suitable acidic pH. The full range of pH values from 1 to 14 were seen, alkaline or strongly acidic pH values suggest that in some cases the apparatus used may not have been clean.

(j) Many candidates correctly identified ammonium chloride. It should be noted that ‘ammonia’ is not a suitable alternative to ‘ammonium’. No tests that could identify aluminium ions were carried out.

Question 3

This planning task was based on a method of obtaining the metal bismuth from a sample of the ore bismite. It was not a quantitative task and so there was no need to specify quantities used. Some candidates tried to list dependent and independent variables, as this was not a quantitative task there were no variables to control or measure.

Good plans included:

- breaking the large lump of bismite up into smaller pieces
- removing soluble impurities by dissolving them in water, filtering and retaining the residue
- adding a named acid to the bismuth oxide obtained to form an aqueous solution of a salt
- obtaining bismuth metal from the salt solution either by electrolysis using inert electrodes or by a displacement reaction using an appropriate more reactive metal.

An alternative to adding a named acid to produce a salt was to add an appropriate reducing agent (such as carbon) to the bismuth oxide and heating the mixture.

Many candidates gained all six marks and gave clear, well structured, methods.

Common errors and omissions were:

- not breaking the large lump of ore into small pieces
- not removing soluble impurities by adding water and then filtering
- making a solution of the salt and then thinking that crystallisation of the salt produced bismuth metal
- adding a metal that is far too reactive to the salt solution made, metals such as sodium will just react with the water rather than displace the bismuth.

Another misconception that was evident in some answers was that adding bismuth oxide to an acid would result in oxygen being made and fizzing. While this is incorrect it did not change the marks awarded to the candidate as marks were awarded for the method used and not observations made during the reactions.

As has been said previously, it is a good idea for candidates to plan out their answers before starting to write them out, this will help to avoid the need for footnotes where the last thing written is intended as the first step of the procedure.

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Practical Test

Key messages

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

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

- In the qualitative analysis question (**Question 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. 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 carrying out the qualitative analysis, if candidates add two solutions and one forms a layer on top of the other, the candidates should mix the contents of the tube together.

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

- In qualitative analysis, not all of the tests described will necessarily give a positive result; a negative test result is useful since it 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. The vast majority of candidates were able to complete all questions in the time available. The paper discriminated successfully between candidates of different abilities but was accessible to all. The paper was generally well answered, with very few blank spaces.

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 majority of candidates successfully completed the investigation and recorded results for both experiments. Almost all candidates obtained results that showed an increasing volume over gas over time in both experiments with the second experiment having a higher volume of gas produced than the first. Most candidates’ final volume for Experiment 1 was close to the Supervisor’s result and temperatures quoted were to the same resolution (the same number of decimal places).

(b) The vast majority of candidates were able to select an appropriate scale and plot the twenty points accurately. The plotting was done well, although some candidates had difficulty reading the *x*-axis and plotted the first point at 10 rather than 15. Several candidates drew graphs without drawing a scale thus credit could not be awarded. When drawing a line of best fit candidates should remember that a best-fit line should be a single, thin, smooth straight-line or curve and that the line does not need to coincide exactly with any of the points.

Many candidates drew an acceptable key but omitted the label altogether.

(c) Many candidates gained full credit here. The best answers included appropriate working on the graph; ideally this would be two vertical lines starting at 50 s and 70 s and going to the graph line and then horizontally across to the *y*-axis where the reading is taken. A common reason for not obtaining full credit was candidates not showing any working on the graph. The candidates then found the difference between the two readings accurately.

Some candidates misunderstood the question of finding the volume collected between 50 s and 70 s and simply read the value from the graph at 60 s. A small number of candidates added the values, or found the mean.

(d) While many candidates correctly stated the faster reaction was Experiment 2, some candidates gave an explanation of 'more gas being collected'. The candidates needed to expand on this and say 'more volume of gas collected in the same amount of time'. A number of candidates used kinetic theory to explain the different rate rather than Fig. 1.2 as instructed in the question. A significant number of candidates correctly identified that a faster reaction has a steeper gradient.

(e) (i) This was almost always answered correctly, although a small minority of candidates stated that temperature would change the rate rather than saying the rate increases as temperature increases.

(ii) The candidates found this question difficult and although a number had the idea that the temperature needed to be controlled, they then did not take this answer far enough by saying a water-bath needed to be used. The majority wanted to insulate the flask in some way to prevent the heat loss or to heat the apparatus with a heating mat – neither method would work to minimise temperature change as the reaction is exothermic and the requirement is to remove the thermal energy released in the exothermic reaction from the flask rather than keep it in the flask.

(f) This was a demanding question that only better performing candidates were able to answer correctly. The candidates did not appreciate that the stopper should not be removed, or the apparatus needed to be kept sealed to prevent gas loss and offered responses such as remove and replace the stopper quickly, put a door in the flask to add the magnesium, use a syringe to add the magnesium. The candidates needed to have the idea that the magnesium and the ethanoic acid had to be kept apart before the reaction. Methods could have included using a divided flask and shaking the flask to initiate the reaction or placing the magnesium in a small tube inside the flask and shaking the flask to start the reaction. The addition of ethanoic acid from a burette into the flask containing the magnesium would not work because the added acid would displace air from the flask which would be collected in the inverted measuring cylinder.

(g) Many candidates could state that the experiment should be repeated but then went on to say that the results should be compared rather than averaging to remove random errors. A handful of candidates used pipettes or burettes to measure the volumes more accurately. It should be noted that collecting gas in a gas syringe does not make the results more accurate.

(h) This question was answered correctly by most candidates who realised that a greater concentration would increase the rate and drew a steeper graph. Some did not attempt this question and candidates are encouraged to check their paper carefully for questions like this that are easy to miss without an answer space.

Question 2

(a) Most candidates correctly stated that the solid **K** turned black when heated strongly. Fewer candidates reported seeing steam being given off or droplets of condensation forming on the walls of the boiling tube. Very few candidates noticed that the powder moved as it was heated.

(b) As substance **K** was copper(II) carbonate, the majority of candidates observed effervescence produced by the formation of carbon dioxide gas. A number of candidates stated that a gas is given off, but this is not an observation. Fewer candidates noticed that a blue or blue-green solution would be formed. Many candidates did not appear to complete the test for the gas with better performing candidates realising that if an acid was being added, this was a test for a carbonate, hence carbon dioxide would be produced, which would turn limewater cloudy.

(c) Many candidates noted the formation of a light blue precipitate which redissolved in excess to form a deep blue solution. Some candidates stated that there was a deep blue layer at the top of the test-tube. It is important when carrying out qualitative reactions that the contents of boiling and test-tubes are mixed when solutions are added together.

(d) Most candidates were able to recognise that solution **L** became green when it was heated. Some stated that it turned blue but for this observation to gain credit they had to say that it turned blue when it was cooled.

(e) (i) This was well answered, with most candidates observing that they would see a colour change to brown or green as solution **L** reacted with the aqueous potassium iodide to make iodine.

(ii) The majority of candidates were able to identify a colour change to blue-black as starch was added to the iodine produced in **(e)(i)**.

(iii) A common response was to state that ‘it turned back to its original colour’. This is not sufficient for an observation and the candidates needed to state what the original colour was i.e., green.

(f) The expected result from the flame test was a blue-green flame and the majority of candidates observed the correct flame colour. A minority of candidates quoted light green flame, which was not creditworthy as this is the test for barium ions. A number of candidates gave results, such as ‘bubbling’ that could not have been obtained from a flame test.

(g) The majority of candidates could state that the solid compound contained copper but fewer recognised that the solid was a carbonate. Some candidates simply named the positive ion from the flame test. It is important that candidates use all the information and the Notes for use in qualitative analysis to help them identify solid **K**.

Question 3

Some excellent and succinct descriptions of this quantitative task were seen.

A common error was to place the alloys in water and time how long it takes for them to rust. Another error was to only leave the alloys for a few minutes.

Most candidates used the same method and gained credit for:
- measuring the initial mass of the alloy
- putting the alloy in a suitable container, such as a beaker or flask, of water
- waiting for a suitable time, such as any time $>$ 1 hour
- finding the mass of the alloy after rusting
- stating the largest increase in mass was the alloy that rusted the most.

Better performing candidates realised that the alloy needed to be filtered and dried before finding the final mass.

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

It should be noted that there is no need for candidates to write a list of aims, apparatus nor independent, dependent and control variables at the start of their answers. The aim of the plan is in the question and credit will not be given for listing items of apparatus. Where credit is available for the selection of an appropriate item of apparatus then it must be clear in the plan for what the item of apparatus will be used.

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Paper 0620/61
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 on page 49 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 'The student tests any gas produced', then candidates are expected to record the details for the gas test that gives a positive result. Candidates are expected to use the term 'precipitate' when describing the formation of a solid from the reaction between two solutions; if when two solutions are mixed the product becomes cloudy and opaque, then a precipitate has been formed. To state that a gas is given off is not an observation. The relevant observation would be effervescence or fizzing or bubbles (of a gas).

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

- In qualitative analysis, not all 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 paper discriminated successfully between candidates of different abilities but was accessible to all. The paper was generally well answered, with very few blank spaces.

In answering the planning question (**Question 4**), there is no need for candidates to write a list of apparatus at the start, 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 were able to name the items of apparatus as a conical flask and a volumetric pipette. A common error was to call the pipette a dropper or dropping pipette, which was not acceptable as that is a different item of apparatus.

(b) (i) Some excellent answer were seen, explaining that the indicator allows the end-point to be detected by changing colour. Some answers just referred to the indicator changing colour and did not give a reason why this is needed; these answers did not gain credit.

(ii) Most candidates correctly suggested methyl orange as a suitable indicator. Phenolphthalein and thymolphthalein were also acceptable answers. It should be noted that universal indicator is not suitable for use in a titration because it shows a gradual colour change and there is no sharp end-point.

(c) The strongest responses described how there was a need to take a reading from the burette before the addition of the hydrochloric acid to the flask and another reading at the end-point; the volume used is then found by subtracting the initial reading from the final reading. Some candidates seemed to be unfamiliar with the procedure for doing a titration and the use of the scale on the burette. There were suggestions of pouring the contents of the flask into a measuring cylinder or even finding the mass of the flask.

(d) The vast majority of candidates correctly stated that the contents of the flask should be mixed; this is best achieved by swirling the flask. Some candidates misunderstood the question and wrote about safety precautions, which should have been taken before the experiment was started.

Question 2

(a) Almost all candidates gained credit for recording the volumes of dilute sulfuric acid and water. The most common error was to not have the volume of water as zero in Experiment 1. Most candidates read the thermometer diagrams to the nearest half scale division (0.5 °C) and correctly subtracted the initial temperature from the temperature after 45 seconds. Many candidates did not record temperature and temperature changes to the same resolution and so recorded, for example, 30.0 °C as 30 °C and so did not gain all five marks for the completion of Table 2.1.

(b) (i) Almost all candidates identified Experiment 5 as having the smallest temperature change.

(ii) Most candidates were able to correctly explain that Experiment 5 had the smallest temperature change because the volume of water was the largest. The very best responses went on to explain that in all 5 experiments the heat energy given out was the same but it was used to increase the temperature of increasingly large volumes of liquid.

(c) While many fully correct graphs were seen, there were a number of common errors, these were:

- inappropriate graph scales. The expected graph scale was each large grid square being equivalent to 2 °C. Candidates who chose more awkward scales, such as each large grid square being equivalent to 2.5 °C or 3 °C very often plotted points incorrectly and so did not gain the credit available for correctly plotting all six points.
- as well as plotting errors caused by the selection of a difficult scale, some candidates incorrectly plotted the point for Experiment 5 at 0.5 °C or 1 °C rather than 1.5 °C.
- drawing a straight line of best fit through the points rather than a curve. If the 'best-fit straight line' has the points at either end of the line on one side and the points nearer the middle of the line on the other side, then that should suggest that the line should be a curve. This was the most common error.

(d) Most candidates indicated on the graph from where they were taking their reading and correctly recorded the expected temperature increase. The recommended method is to draw a vertical line from the required position on the *x*-axis (7.5 cm^3) up to the graph line and then horizontally across to the *y*-axis in order to make the required reading. Common errors were to work from 7 cm^3 rather than 7.5 cm^3 or to draw construction lines on the graph which were some way from the vertical or horizontal.

(e) This calculation was well answered by many candidates. The most common error in the numerical value was to truncate the number to 0.26 rather than round it correctly to 0.27. The units of the average rate of temperature increase are determined by dividing the unit for temperature change (°C) by the unit for time (s), giving °C / s.

(f) (i) Better responses correctly stated that cotton wool was an insulator and that this would mean there would be less heat loss from the boiling tube and so the temperature change measured would be more accurate. A common error was to state that the cotton wool would keep the temperature constant, as the temperature change is the dependent variable in this investigation. Keeping it constant would defeat the purpose of the investigation. Some candidates confused the use of cotton wool with investigations into the rate of reaction by following the mass of gas lost.

(ii) Most candidates correctly stated that the volumetric pipette would only measure a fixed volume. Better answers when on to explain that in no experiment was the volume of water 25.0 cm^3. A common error was to confuse a volumetric pipette with a dropping (Pasteur) pipette or to think that the slow addition of water from the pipette would be a problem; as the water is added to the acid before the reaction starts, slow addition is not a problem.

(iii) Many candidates suggested using a burette to improve the accuracy but did not say what the burette would be used for or in place of and so did not gain credit. One of the more common errors was to use a digital thermometer. There is no reason why a digital thermometer should be more accurate than a liquid in glass thermometer; indeed, a digital thermometer depends on electrical components and as their capacitance or resistance can change over time, the temperatures shown can drift from the true value. A digital display that can read to 0.1 °C does not necessarily mean greater accuracy.

(g) Most candidates realised that a shorter length of magnesium ribbon would result in less heat energy being given out to the solution and so a smaller temperature change. It was a relatively common error to have the sketch line joining the plotted line at one or both ends, in reality if less energy is given out then the temperature change will be lower for all volumes of water added.

Question 3

(a) The majority of candidates were able to use the Notes for use in qualitative analysis on pages 15 and 16 of the examination paper and correctly stated that on dropwise addition of aqueous sodium hydroxide, a green precipitate would form and that in excess the precipitate would dissolve. A small number candidates, having correctly stated the expected observations went on to incorrectly say that a colourless solution would be formed. This prevented the awarding of credit for stating that the solution formed would be green.

(b) Most candidates correctly suggested that a cream precipitate would form. Some candidates added additional incorrect observations, such as effervescence, and so did not gain credit.

(c) The question asked for a chemical test to show the condensation contained water. A significant number of candidates gave a physical test for the purity of water and so did not gain the credit available. The expected test reagent was anhydrous copper(II) sulfate or anhydrous cobalt(II) chloride. While many candidates gave correct reagents and the matching colour observed, some candidates mixed the reagents or colours up and so had anhydrous cobalt(II) chloride turning blue or suggested reagents such as anhydrous copper(II) chloride.

(d) Stronger responses correctly stated that a flame test should be used. By far the most common incorrect answer was to state that aqueous ammonia should be added. The test results provided in Table 3.1 showed that there was no change when aqueous sodium hydroxide was added dropwise or in excess. Looking at the Notes for use in qualitative analysis on page 15 it shows that for cations covered by this syllabus, if there is no positive result when testing using aqueous sodium hydroxide then there will also be no positive result when testing with aqueous ammonia.

(e) The majority of candidates correctly identified sulfate as the anion in solid **F**. A number of candidates suggested sulfite, presumably because the test for sulfite ions had been carried out, although the result was negative because the acidified potassium manganate(VII) solution was not decolourised.

Question 4

Some excellent and succinct descriptions of how to obtain pure samples of each component of the mixture were seen. As this was a qualitative tas,k there was no need to control masses or volumes.

The simplest route through the separation task was:
- filter the mixture to obtain ethanol as the filtrate
- add the residue from the filtration to water and stir to dissolve the sodium chloride
- filter the mixture to obtain zinc carbonate as the residue and aqueous sodium chloride as the filtrate
- wash and dry the zinc carbonate
- warm the filtrate to evaporate all of the water and leave behind solid sodium chloride.

Other processes, such as fractional distillation to obtain ethanol after the addition of water, would also work and could have gained full credit.

Some of the more common errors were:
- adding ethanol to the mixture and then obtaining ethanol from the mixture. This action meant the credit for obtaining a sample of ethanol could not be awarded.
- not washing and drying the zinc carbonate after filtration.
- failing to add water to the mixture, meaning it was not possible to separate the zinc carbonate from the sodium chloride. It is possible that candidates who did this had not read the question carefully and had assumed the mixture already contained water.
- not trying to separate a mixture at all, instead carrying out tests on individual substances. This approach did not answer the question asked and so could not receive any credit.

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Paper 0620/62
Alternative to Practical

Key messages

- In the qualitative analysis question (**Question 3**) where a question states 'and test any gas produced' 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. When two solutions are mixed, if the product becomes cloudy and opaque then a precipitate has been formed.

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

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

- To state that a gas is given off is not an observation. The relevant observation would be effervescence or fizzing or bubbles (of a gas).

General comments

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

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. 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 correctly identified the pieces of apparatus as a boiling tube or test-tube and a measuring cylinder, although a graduated cylinder was also acceptable for the latter.

(b) Most could also place the 'heat' arrows in the correct places, although a few heated the water in the boiling tube or the trough.

(c) Water was the most common answer, although aqueous ammonia was also accepted.

(d) Roughly half the candidates realised that no ammonia was collected as it had dissolved in the water. Most incorrect answers were based on ammonia's low (or high) density.

(e) This was more challenging, with a minority realising that the first few bubbles would be air that was in the apparatus at the start of the experiment.

(f) The expected answer was that ammonia is a toxic gas. However, a few answers suggested that other gases, such as chlorine or nitrogen were toxic or that ammonia was a flammable gas, which is incorrect.

Question 2

(a) The vast majority of candidates successfully completed the table with all six burette readings correct and most went on to calculate the titre correctly by subtraction. A few appeared to believe that the initial reading on a burette is 50.0 cm^3. The most common error was to not record all volumes to one decimal place, such as 28 rather than 28.0 cm^3. Two decimal places were also accepted as long as used consistently.

(b) About half the candidates correctly gave the colour change of the thymolphthalein indicator as blue to colourless.

(c) Almost all candidates knew that the flask was swirled to ensure even mixing of the reactants or to ensure complete reaction.

(d) This was more challenging with candidates having to explain why a black background was used in this titration. Most realised that it was to make the end-point of the titration more easily visible, which was, in this case, the appearance of a white cloudiness rather than the usual colour change.

(e) (i) Nearly everyone realised that the measuring cylinder needed rinsing between Experiments 1 and 2 to remove traces of the previous solution, **F**.

(ii) The vast majority of candidates correctly stated that rinsing was not necessary as the same solution was being used in the measuring cylinder in both Experiment 2 and 3.

(f) Candidates were asked which solution, **F** or **G**, was most concentrated. As 25 cm^3 of each of these solutions were measured into the conical flask, it was solution **G**, as it needed the largest volume of aqueous aluminium chloride from the burette to cause neutralisation. Candidates were evenly split between **F** and **G**. Credit was also available for realising that the concentration/titre was double for one of the solutions and was awarded even if they had chosen the incorrect solution.

(g) This calculation provided a large number of correct answers, although a few forgot to add the unit.

(h) The question was assessing why a volumetric pipette could **not** be used to measure the volume of aqueous aluminium chloride. In other words, why could it not be used in place of a burette. The answer is that a volumetric pipette cannot measure a variable volume, unknown at the start of the titration.

Question 3

(a) (i) Candidates were not good at giving observations. In this question, credit was for effervescence, fizzing or bubbles and limewater going milky. The formation of a colourless solution was accepted as an alternative to fizzing. Few candidates gained full credit and usually omitted the limewater test.

(ii) Nearly all candidates correctly stated that the gas produced was carbon dioxide, even if they had not mentioned the limewater test in **(i)**.

(b) Nearly all candidates gained credit for using the ‘Notes for use in qualitative analysis’ to state that barium compounds gave a light green flame test.

(c) Very few realised that the correct answer was that the solution would turn (from colourless) to pink or purple because of the addition of potassium manganate(VII). Some did say that the solution would stay purple which was an acceptable answer. A common answer that did not gain credit was to state that there would be no change; this was not accepted as the colourless solution **J** becomes pink on addition of potassium manganate(VII), so although no reaction occurs there is a visible colour change.

(d) The expected observation was that there would be a white precipitate formed as sulfuric acid is added to aqueous barium nitrate. Fewer than half the candidates answered this correctly.

(e) This was a challenging test as candidates needed to realise that aqueous barium nitrate was being added to aqueous barium nitrate, so there would be no reaction; it was a negative sulfate test.

(f) (i) Nearly everyone could identify the gas as ammonia.

(ii) Nearly everyone realised that ammonia would have no effect on damp blue litmus paper.

(g) Most candidates gained full credit here for ammonium chloride, although aluminium and zinc appeared frequently as incorrect alternatives to the ammonium ion.

Question 4

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

This was a qualitative task based on the extraction of metals from their ores, specifically bismuth from bismite.

As a lump of bismite was provided credit was available for converting this into smaller pieces or a powder, and the apparatus used, commonly a mortar and pestle or a hammer.

Soluble impurities could then be removed by dissolving them in water and filtration to leave bismuth(III) oxide.

There were alternative routes at this point. Candidates were told that bismuth had similar reactivity to copper, so they could now reduce the oxide directly by heating it with, for example, carbon, However, most candidates chose to convert the bismuth(III) oxide into a salt solution by reacting it with a named acid. Again there was a choice, displacement using a more reactive metal or electrolysis of the aqueous solution using inert electrodes. There was roughly an even split between these alternative routes. Possibly displacement was the slightly easier route, although a minority did choose an unsuitable metal such as sodium. A large number of candidates stopped after the addition of an acid, thinking that crystallisation would leave crystals of bismuth.

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Paper 0620/63
Alternative to Practical

Key messages

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

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

- In the qualitative analysis question (**Question 3**), 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).

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General comments

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

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. 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 were able to state why the rock salt was made into smaller pieces but some did not go far enough and simply stated to dissolve the salt or to mix the salt or to make it smaller.

(b) Most candidates were able to correctly identify the apparatus needed as a Bunsen burner with a few candidates incorrectly using flames or heating mats or a hot plate.

(c) Candidates were less successful at naming apparatus **A** and commonly stated it was a filter as opposed to a funnel. A few candidates used the term 'embudo'; candidates should be mindful that the syllabus term for this paper is 'funnel'.

(d) The candidates found this question challenging. While most had the idea that the aqueous sodium chloride needed to be heated to evaporate the water, many just stated evaporate the water rather than suggest a method to evaporate the water. Only the strongest answers suggested that the solution needed to be heated to the point of crystallisation and then offered a method of drying as opposed to simply stating ‘dry the salt’.

Question 2

(a) Almost all candidates gained credit for recording the initial and final temperatures. A small number of candidates did not record the thermometer readings to half a scale division. Credit was also awarded for calculating the average, which the majority of candidates did well; although a few either found the difference in the readings, or added them together. Only the better performing candidates recorded all 6 readings to the same resolution (the same number of decimal places).

(b) This was done well by all candidates who read all 10 volumes from the measuring cylinders correctly.

(c) The vast majority of candidates were able to select an appropriate scale and plot the points accurately. However, several candidates used more complicated scales, such as having each large grid square = 18, which made plotting the points (or data) more difficult. The plotting was done well, although some candidates had difficulty reading the *x*-axis and plotted the first point at 10 rather than 15. When drawing a line of best fit candidates should remember that a best-fit line should be a single, thin, smooth straight-line or curve and that the line does not need to coincide exactly with any of the points. In these experiments the points lay on a curve.

Candidates were instructed to label both curves; many drew an acceptable key but then omitted the label altogether.

(d) Many candidates gained full credit here. Appropriate working needed to be shown on the graph; ideally this was two vertical lines starting at 20 s and 40 s and going to the graph line and then horizontally across to the *y*-axis where the reading is taken. Many candidates did not show this working on the graph. The candidates then found the difference between the two readings accurately.

Some candidates misunderstood the question of finding the volume collected between 20 s and 40 s and simply read the value from the graph at 30 s. A small number of candidates added the values, or found the mean.

(e) While many candidates correctly stated the faster reaction was Experiment 2; a common answer was ‘more gas was collected’ but the candidates needed to expand on this and say ‘more volume of gas collected in the same amount of time’. A number of candidates used kinetic theory to explain the different rate rather than Fig. 2.2 as instructed in the question. A significant number of candidates correctly identified that a faster reaction has a steeper gradient.

(f) (i) This was almost always answered correctly, although a small minority of candidates stated that temperature would change the rate rather than saying the rate increases as temperature increases.

(ii) The candidates found this question difficult and although a number had the idea that the temperature needed to be controlled, they then did not take this answer far enough by saying a water-bath needed to be used. The majority wanted to insulate the flask in some way to prevent the heat loss or to heat the apparatus with a heating mat – neither method would work to minimise temperature change as the reaction is exothermic and the requirement is to remove the thermal energy released in the exothermic reaction from the flask rather than keep it in the flask.

(g) This was a demanding question that only the better performing candidates were able to answer correctly. The candidates did not appreciate that the stopper should not be removed, or the apparatus needed to be kept sealed to prevent gas loss and offered responses such as remove and replace the stopper quickly, put a door in the flask to add the magnesium, use a syringe to add the magnesium. The candidates needed to have the idea that the magnesium and the ethanoic acid had to be kept apart before the reaction. Methods could have included using a divided flask and shaking the flask to initiate the reaction or placing the magnesium in a small tube inside the flask and shaking the flask to start the reaction. The addition of ethanoic acid from a burette into the flask containing the magnesium would not work because the added acid would displace air from the flask which would be collected in the inverted measuring cylinder.

(h) Many candidates could state that the experiment should be repeated but then went on to say that the results should be compared rather than averaging to remove anomalies. A handful of candidates used pipettes or burettes to measure the volumes of ethanoic acid more accurately. It should be noted that collecting gas in a gas syringe does not make the results more accurate.

(i) This question was answered correctly by most candidates who realised that a greater concentration would increase the rate and drew a steeper graph. Some did not attempt this question and candidates are encouraged to check their paper carefully for questions like this that are easy to miss without an answer space.

Question 3

(a) Most candidates correctly stated that effervescence would be seen with a handful saying a gas is made, which is not an observation.

(b) The test for copper ions was well known by the vast majority of candidates. Candidates should make sure they state the precipitate and its colour before saying if the precipitate is soluble or insoluble. A few candidates did not gain any credit for stating the deep blue solution was formed before the light blue precipitate.

(c) (i) Almost all candidates gained credit for correctly stating that the colour of the flame would be blue-green.

(ii) Candidates found describing the method of a flame test challenging and only the strongest responses gained any credit here. The description of the test was often vague and candidates wanted to put the sample ‘in a Bunsen’, ‘near a Bunsen’, ‘over a flame’, ‘near a flame’ – the sample must be **in** the flame for a flame test to work. The candidates needed to state a method of getting the sample **into** the flame e.g., ‘put the sample on a nichrome wire and place the sample **into** a blue flame’.

(d) The majority of candidates identified calcium bromide correctly. A few stated aluminium bromide - candidates should be encouraged to check their answers using ‘tests for cations’ table provided.

Question 4

Some excellent and succinct descriptions of this quantitative task were seen.

A common error was to place the alloys in water and time how long it takes for them to rust. Another error was to only leave the alloys for a few minutes.

Most candidates used the same method and gained credit for:
- measuring the initial mass of the alloy
- putting the alloy in a suitable container, such as a beaker or flask, of water
- waiting for a suitable time, such as any time $>$ 1 hour
- finding the mass of the alloy after rusting
- stating the largest increase in mass was the alloy that rusted the most.

Better performing candidates realised that the alloy needed to be filtered and dried before finding the final mass.

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

It should be noted that there is no need for candidates to write a list of aims, apparatus nor independent, dependent and control variables 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.