CHEMISTRY

Paper 0620/11
Paper 1 Multiple Choice (Core)

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

General comments

Candidates found this a challenging paper. A minority of candidates achieved more than 50% of the available marks. **Questions 1**, **15**, **23**, **31** and **33** had the least demand whereas **Questions 2**, **8**, **11**, **12**, **17**, **20**, **24** and **27** had the highest demand. High demand questions often required recall of more than one part of the syllabus. Reactions of the elements in Group I or Group VII were not well recalled or understood. The physical appearance of chemicals, especially as result of syllabus tests, was not well recalled.

Comments on specific questions

Question 2

Most candidates chose option **B**, the alloy, as an example of a pure substance. Candidates are reminded that alloys are defined as a mixture rather than a pure substance.

Question 3

This question discriminated well between candidates. Candidates who performed less well overall were much more likely to choose options **C** or **D** suggesting some confusion about the movement of charge when Group **I** elements react to form ions.

Question 8

Candidates often find questions involving calculations challenging. Just over one fifth of the candidates were able to use the ratio of relative masses to calculate the mass of methane. Option **B** was the most common choice which suggests some understanding of stoichiometry.

Question 11

This question showed some discrimination but only two thirds of candidates answered this question correctly. Option **A** was chosen by almost half of the candidates overall which suggests that the link between the term 'exothermic' and change in temperature is well known but their connection to the reaction pathway diagram is confused.

Question 12

Questions on physical and chemical changes are often well answered but many candidates found this question difficult. Option **D** was chosen by the majority of candidates. Perhaps the word 'producing' suggested a reaction product from a chemical change rather than a physical change.

Question 14

All of the options were commonly chosen with option **C** being the popular incorrect answer.

Question 17

Questions which require the recall of more than one syllabus statement are more challenging. Most candidates found this question challenging, with even the more able candidates appearing to be guessing. Overall, the correct answer was the least likely to be chosen.

Question 20

Candidates often did not recognise that the question was asking them to identify the substance containing a transition element. Candidates should recognise that one of the characteristics of transition elements is their ability to form coloured compounds and this sets them apart from other metals such as those from Group **I**.

Question 21

Most candidates recalled that elements from Group V**II** each had seven electrons in their outer shell. Many confused the order of reactivity or their physical state at room temperature. Option **B** was a common incorrect answer.

Question 24

This was a challenging question and required some deductive reasoning. Option **C** was the most common answer. Candidates should recall that all aqueous halide ions are colourless.

Question 27

Some candidates thought that calcium carbonate was a reaction product in the extraction of iron in a blast furnace. Candidates should recall that calcium carbonate would thermally decompose and so cannot be a reaction product.

Question 38

Most candidates were unsure about the term 'complete combustion'. For the complete combustion of ethane, all the carbon atoms would become carbon dioxide. Option **B** was the most common answer.

Question 39

This question required candidates to interpret the state symbols and identify that a separation method for solids and solutions is needed. Most candidates suggested option **C**, distillation, which is a process that would remove water but not the calcium hydroxide from the rest of the mixture.

Question 40

Ion tests were not well recalled. Errors were made in both the identification of the iron ion and the nitrate ion. Overall, the distribution of answers suggests many candidates were guessing.

CHEMISTRY

Paper 0620/12
Paper 1 Multiple Choice (Core)

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

General comments

Candidates found **Questions 4**, **8**, **24**, **26** and **30** to be least demanding and **Questions 5**, **6**, **11**, **13**, **20**, **27** and **34** to be most demanding.

Syllabus content about types of bonding and the properties of substances was often not well recalled.

Comments on specific questions

Question 5

This question was not well answered. All the other options were more popular than the correct answer. Option **A** was the most common incorrect answer, suggesting poor recall of ionic bonding.

Question 6

The distribution of answers suggests that many candidates were guessing. When answering questions like this, candidates are advised to consider a simple compound they know well and to check whether the statements they choose can be applied to that compound.

Question 10

Calculations are often found to be demanding. Although the correct answer was the most chosen option overall, option **A** was a common incorrect answer.

Question 11

Some candidates were more likely to choose any one of the other answers rather than the correct answer. Option **A** was the most popular choice overall. The difference between reaction products when electrolysing molten rather than aqueous electrolytes was often not well recalled.

Question 13

Fewer than one in five candidates answered this correctly. Option **C** was the most common incorrect answer with candidates confusing endothermic and exothermic reactions.

Question 14

Most candidates correctly identified that decreasing the concentration would not lead to an increase in reaction rate. The impact of changes to the surface area of a solid was not so well recalled and option **C** was chosen almost as commonly as the correct answer.

Question 20

Candidates appear to have recalled that lead compounds are frequently insoluble, but did not always recall that all nitrates are soluble. Option **B** was the most chosen answer. A significant number of candidates chose option **D**, perhaps confusing sodium carbonate with calcium carbonate.

Question 21

Most candidates recognised that the element could not be from Group VIII of the Periodic Table. Fewer candidates recalled that transition elements typically have high melting points and form coloured compounds. Over a third of the candidates chose option **D**.

Question 27

The link between reactivity and the extraction of the metal from its oxide using carbon is a common cause for confusion. Option **C** was chosen by a third of the candidates.

Question 34

Few candidates mistook the structure in option **A** for ethanoic acid. The structure shown for the correct answer, option **C**, appeared to confuse candidates and so options **B** and **D** were more likely to be chosen. Candidates are reminded that carbon will only form four covalent bonds.

Question 35

Option **A** was the most popular answer. Candidates are reminded that petroleum is a mixture of different hydrocarbons which must be separated before any use is to be made of them. Fractional distillation must therefore be the first stage.

Question 39

Nearly all candidates identified option **D** as being incorrect. Other solid mixtures given in options **A** and **B**, were not so readily rejected.

CHEMISTRY

Paper 0620/13
Paper 1 Multiple Choice (Core)

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

General comments

Candidates found **Questions 3**, **9**, **27**, **29**, **33** and **38** to be least demanding and **Questions 10**, **12**, **13**, **16**, **32**, **36** and **40** to be most demanding.

Questions from the topic of electrolysis and fuel cells were not well answered. Questions which required the interpretation of a diagram were also not well answered, particularly by candidates who performed less well overall.

Comments on specific questions

Question 4

Most candidates recalled that sodium forms positive ions. Some candidates thought that this is because the atoms gain rather than lose electrons. Option **A** was the most common incorrect answer.

Question 10

This question was found to be the most demanding on the paper and few candidates answered it correctly. Most candidates chose option **A** or option **B**, by incorrectly assuming that a compound of sulfur is produced when sulfuric acid is electrolysed.

Question 12

The hydrogen–oxygen fuel cell was not well recalled. Many candidates thought that the fuel was petrol or that carbon dioxide would be produced. Option **C** was chosen by half of all candidates.

Question 13

The distribution of answers suggests than many candidates were guessing. The interpretation of the question was of a high demand, and some candidates were more likely to choose option **C**, the reaction pathway diagram for the forward reaction.

Question 16

Option **C** was the most common incorrect answer where candidates correctly linked 'thermal' to heating or the use of 'hot copper(II) oxide' but were unsure about the meaning of 'decomposition'.

Question 24

This question discriminated well between candidates. Candidates who performed less well overall commonly chose option **B** or option **D**, properties not associated with transition elements.

Question 27

Some candidates appeared to confuse the structure of an alloy with that of a gas and chose option **A**.

Question 28

Candidates frequently confused the reactivity of a metal and the ease of its extraction from its oxide using carbon. Option **B** was the most commonly chosen incorrect answer.

Question 30

This question discriminated well between candidates. Most candidates who performed less well overall recognised that swimming pools were chlorinated but did not recall the role of chlorine in killing microbes in drinking water. The most common answer by these candidates was option **D**.

Question 32

Fewer than one third of the candidates identified the source of oxides of nitrogen in exhaust gases. Options **B** and **D** were the most common answers.

Question 36

This question was not well answered. Most candidates appeared to have confused the reactions of ethane with those of ethene. Option **D** was the most common incorrect answer.

Question 40

This question was not well answered. Although a small majority of candidates identified chromium(III) as the cation, only a minority of candidates identified the halide as a bromide ion. Option **B** was chosen by a third of the candidates.

CHEMISTRY

Paper 0620/21
Paper 2 Multiple Choice (Extended)

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

General comments

Overall, candidates found this to be an accessible paper. **Questions 1**, **3**, **6** and **26** had the lowest demand and **Questions 8**, **12**, **19**, **33**, **34** and **36** had the highest demand. Many questions showed strong discrimination between candidates. Candidates should take care to read each option carefully so that any partially correct answers can be excluded.

Comments on specific questions

Question 4

This question discriminated well between candidates. Some candidates chose option **B** by not recognising that the atoms were isotopes of the same element.

Question 8

Knowledge of the hydrogen–oxygen fuel cell and its role in producing electrical energy was often not well recalled. A third of candidates overall chose option **B**.

Question 12

Nearly half of all candidates chose option **D**. Perhaps a confusion in the meaning of the word ‘producing’ suggested to candidates that this was a chemical rather than physical product.

Question 17

This question discriminated well between candidates. Some candidates chose option **D** which gives an incorrect symbol for the ion produced in acidic solutions.

Question 19

The distribution of the options chosen by candidates suggests that many were guessing. Where state symbols are provided, candidates are advised to use them to help answer the question. In this question, the solid product should identify the precipitation.

Question 20

Some candidates did not recognise that the question required them to identify the transition element present in the options. They should be reminded that Group **I** elements generally form white solids and colourless solutions.

Question 28

This was the most strongly discriminating question on this paper. Few of the candidates that performed less well overall answered this correctly and were more likely to choose any of the other options, with the majority confusing the terms anode and cathode.

Question 30

Most candidates recalled the role of catalytic converters in the reduction of oxides of nitrogen from exhaust gases. The source of the oxygen or nitrogen to form these gases was not well recalled. Option **D** was the most common incorrect answer.

Question 33

This was found to be a demanding question. Most recalled the role of ultraviolet light in the reaction. Only a minority of candidates recognised the equation given in statement 3 as incorrect. Hydrogen is not a reaction product of this substitution reaction. Option **C** was the most common answer.

Question 34

Many candidates confused esterification with the oxidation of an alcohol and suggested option **A**.

Question 36

Recall of the properties of these polymers was poor. Many candidates did not recall that nylon is a polyamide and will therefore produce more than two different compounds when completely combusted. Some candidates appeared to be guessing. Option **B** was the most common answer.

Question 37

Candidates who performed less well overall were more likely to choose any of the other options in preference to the correct answer, not identifying either the correct reactant or excluding carbon monoxide as an incorrect reaction product.

Question 39

The state symbols were not used by some candidates to identify the solid and so they did not choose filtration as a suitable separation method. Option **C** was the most common incorrect answer.

CHEMISTRY

Paper 0620/22
Paper 2 Multiple Choice (Extended)

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

General comments

Overall, candidates found this to be an accessible paper. **Questions 3**, **7**, **27** and **28** had the lowest demand and **Questions 12**, **13**, **16**, **19** and **32** had the highest demand. There was a good distribution of marks with some candidates doing particularly well. Organic chemistry, in particular the structures of molecules, was a strong discriminator between candidates.

Comments on specific questions

Question 5

This question discriminated well between candidates with some candidates more likely to choose any of the incorrect options. Option **A** was most commonly chosen, showing some confusion about bonding in compounds of the Group **I** elements.

Question 8

Candidates who performed less well overall appeared to be guessing. A significant number of candidates chose option **D** which suggests some confusion about the meaning of the term ‘empirical formula’.

Question 10

The products of the electrolysis of molten and aqueous salts were confused by many of the candidates who performed less well overall. Option **B** was a common incorrect answer.

Question 12

This question was not well answered, and the distribution suggests some candidates were guessing. The most common incorrect answer was option **C** where candidates confused the terms endothermic and exothermic.

Question 13

Perhaps due to confusion between the terms endothermic and exothermic, this question was poorly answered. The combustion reaction shown in option B was the most commonly chosen answer.

Question 16

A small majority of candidates identified the correct direction of movement for the position of equilibrium but confused the effect of temperature on the rates of both the forward and backward reactions. Option **C** was chosen by more than a third of the candidates.

Question 19

Candidates were more likely to choose any of the other options than the correct answer. Option **B** was a popular answer. Although the precipitation reaction is correctly described, it is not correct to describe it as an acid-base reaction.

Question 21

Some candidates appeared to have been guessing.

Question 32

Most candidates identified the reaction in a catalytic converter, but many candidates were confused as to the source of the nitrogen and oxygen which form the oxides of nitrogen. Option **C** was the most common answer.

Question 33

This question discriminated well between candidates. Option **B** was chosen by a third of the weaker candidates. This shows recognition of the carbon–carbon double bond in an alkene but not that carbon can only form four bonds.

Question 37

Some candidates thought that nylon is a polyester rather than a polyamide and chose option **D**. A significant number also confused condensation and addition polymerisation and chose option **A**.

Question 38

Few candidates chose options **A** or **D**. Candidates who performed less well overall were more likely to choose option **B**, which shows carbon making more than four bonds.

CHEMISTRY

Paper 0620/23
Paper 2 Multiple Choice (Extended)

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

General comments

Overall, candidates found this to be an accessible paper. **Questions 3**, **6**, **7**, **16**, **24** and **25** had the lowest demand and **Questions 10**, **22** and **33** had the highest demand. There was a good distribution of marks with some candidates doing particularly well. Questions which link to practical tasks and expected observations, such as **Questions 12** and **22**, were not well answered.

Comments on specific questions

Question 8

A third of the candidates who performed less well overall chose option **D**. Where water is stated as a substance, then candidates should assume that it is pure water rather than tap or another water source which would contain dissolved substances.

Question 10

This question was not well answered. Calculations often have a higher demand, but this question was found to be particularly challenging. The majority of candidates did not engage with the number of ions and just multiplied the number of ions given for $AgNO_3$ by 0.25. Option **B** was therefore the most commonly chosen option.

Question 11

This question discriminated well between candidates. Candidates who performed less well overall were more likely to confuse the positive and negative electrodes, with option **C** commonly chosen by these candidates.

Question 12

Some candidates appeared to have been guessing. Some candidates may have been confused by the terms ‘anode’ and ‘cathode’. When answering questions about electrolysis candidates should note whether the electrodes used are inert to help determine expected observations.

Question 17

This question discriminated well between candidates. Candidates who performed less well overall confused the rate of reaction with yield of ammonia and commonly chose either option **A** or option **C**.

Question 18

Option **C** was the most common incorrect answer where candidates correctly linked ‘thermal’ to heating or the use of ‘hot copper(II) oxide’ but were unsure about the meaning of ‘decomposition’.

Question 20

Candidates who performed less well overall confused the meaning of the terms ‘weak’ and ‘dilute’ with respect to the properties of an acid. Option **A** was commonly chosen.

Question 22

This question was not well answered. Many of the candidates assumed that zinc oxide would show fizzing with dilute hydrochloric acid and chose option **C**.

Question 30

The key reactions in the blast furnace described in the syllabus should be well known by candidates. Option **D** was a common answer. Candidates should recognise that carbonates will thermally decompose and that the question required the extraction of iron rather than a reaction of iron.

Question 32

This question discriminated well. ‘Combustion’ was a common misconception with option **A** chosen by many candidates. These candidates may have been thinking about how an oxide is formed rather than how the oxides of nitrogen are removed using a catalytic converter.

Question 33

This was found to be a challenging question. Nearly half of the candidates chose option **C** which shows two representations of the same molecule. Most candidates recognised that option **A** was impossible by counting the atoms present. Candidates could consider making a simple sketch of the displayed formulae of each option to help identify the correct answer.

Question 35

Candidates who performed less well overall were more likely to choose any of the other options than the correct answer. Option **A** was the most common incorrect answer.

Question 39

More than a third of the candidates who performed less well overall identified statement 3 as being correct but incorrectly assumed the R_f values were independent of the solubility of the substance. Options **B** and **C** were commonly chosen.

CHEMISTRY

Paper 0620/31
Paper 3 Theory (Core)

Key messages

- Candidates would benefit from learning the syllabus definitions of chemical terms and processes.
- Candidates should avoid restating information given in the question as their answer.
- Interpretation of data and the prediction of physical properties using data was generally accurate.
- Candidates should check that they have answered all the questions on the paper, particularly those which require then to add to a diagram or graph and so do not have a separate answer line.

General comments

Many candidates found this to be a challenging paper.

Questions on organic chemistry had the highest demand. The properties and uses of the fractions of petroleum, **Questions 2(b)(i), 2(b)(ii) and 2(b)(iv)** were not well recalled and many candidates gave no answer to these questions. The reactions of organic compounds such as the neutralisation of ethanoic acid in **Question 7(c)** were not well recalled.

Candidates should take care to ensure that their answer matches the question asked. Candidates gave statements in **Question 3(b)(i)** which were correct, but which did not answer the question and so could not be credited. In **Question 4(d)**, some candidates described the effect of pressure on the rate of reaction rather than the volume of a gas. In **Question 5(c)(i)**, candidates described a property of an alloy rather than a comparison of a property between and alloy and a pure metal. In **Question 8(a)**, most candidates described how an ionic bond forms rather than what the bond is.

Candidates were typically able to use and interpret data well with **Questions 3(a)(i), 3(a)(ii), 5(a)(i), 5(a)(ii)** and **6(a)(i)** all answered correctly by most candidates.

Questions which required candidates to add to a diagram or grid were not well answered. **Questions 2(b)(i), 6(a)(ii)** and **7(a)(i)** were not attempted by large numbers of candidates.

Chemical tests were not well recalled. For example, **Question 3(b)(v)** and **Question 7(b)(ii)** were not attempted by almost half of the candidates. Many that did attempt these questions suggested ‘white precipitate’ as the observation.

Candidates need to practise writing both word and symbol equations for the reactions in the syllabus, particularly those for metals and for organic reactions. Many candidates appeared to rely on switching the chemical names of reactants around. Incorrect reaction products were commonly given in **Questions 6(c), 7(c)** and **7(d)**.

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 6(d)**, only a small number recalled that catalysts are not used up in a chemical reaction. In **Question 7(b)(iii)**, few candidates mentioned that polymers were long chain compounds or that they were made using smaller units called monomers.

Comments on specific questions

Question 1

Candidates found the recall of the properties and uses of the listed chemicals to be challenging. **Questions 1(b)**, **1(d)** and **1(f)** were commonly answered correctly but a significant number of candidates for each question appeared to be guessing.

(a) Many candidates recognised that the substance required was an indicator but chose litmus or methyl orange. Some candidates appeared to be guessing.

(b) The use of nitrogen containing salts in fertilisers was not well recalled. The most common incorrect answers were thymolphthalein or sulfur dioxide.

(c) Many candidates identified an ionic substance but not the correct ionic substance. Copper(II) chloride and sodium chloride were common incorrect answers.

(d) Most candidates could identify a gaseous compound but not the correct gaseous compound. Carbon monoxide was the most common incorrect answer.

(e) Many candidates did not use the information that the substance required is a hydrocarbon. Sodium sulfate was a common incorrect answer. Of those that did choose a hydrocarbon, ethene was the most common incorrect answer.

(f) Only around a third of candidates could identify the compound which contains a transition element.

Question 2

Although most candidates could describe how distillation works, few could recall properties or uses of the fractions and many did not attempt **(b)**.

(a) Most candidates could describe at least one of the physical changes which occur during distillation. Some candidates only gave a partial answer, identifying the boiling of water but not the later condensing and collection to complete the separation.

(b) (i) Most candidates did not attempt this question. Where no answer line is provided, candidates should read the question carefully so that it is completed appropriately. Ticking off the mark allocation, e.g. [1] at the end of the question when complete may help them to identify questions which they did not attempt.

(ii) Many candidates did not attempt this question. Candidates could consider learning a suitable mnemonic to recall the order of the fractions.

(iii) Where the fractions of petroleum show a trend in physical properties, the order of the trend will mirror the order of the fractions in the fractionating column. When predicting the lowest or highest boiling points, candidates should look at the fractions at the top and bottom of the column and consider the properties of those substances.

(iv) Many candidates confused bitumen with gasoline and suggested that it was used as a fuel for cars.

Question 3

This was the best answered question on the paper. Candidates showed good skill in extracting and interpreting data from the table.

(a) (i) Nearly all candidates answered this correctly.

(ii) This question was well answered.

(iii) Most candidates were able to extract the information and determine the mass of SO_2 in 250 cm^3 of polluted air. Some candidates calculated the mass in 200 cm^3 or just 1 cm^3 of air.

(b) (i) A number of different possible answers were accepted for this question. Some candidates incorrectly identified other pollutant gases or described the effects of sulfur dioxide on the atmosphere rather than a source of sulfur dioxide.

(ii) Candidates should avoid repeating the question in their answer. Several described the adverse effect of sulfur dioxide as being 'an air pollutant', which was not sufficient.

(iii) Many candidates answered this correctly, but the incorrect option 'sulfuric acid' was commonly chosen.

(iv) The majority of candidates could partially complete the symbol equation; fewer could do so completely.

(v) Very few candidates could recall the test for sulfur dioxide. Many did not attempt this question.

(c) (i) Most candidates gave no answer to this question. Some suggested water or hydrogen.

(ii) Most candidates answered this correctly.

Question 4

This question showed good discrimination between candidates. Better performing candidates tended to make good descriptions of particle arrangements in different physical states and could describe how pressure affects the volume of a gas.

(a) Candidates should take note whether the question is asking for the general properties of a liquid (or solid or gas) or whether the question is asking about the arrangement of the particles within the substance. This question required candidates to describe the general properties of a liquid and not the particle arrangement.

(b) Most candidates correctly identified the changes in physical state. A few incorrectly stated the name of the reverse processes or suggested sublimation which is not on this syllabus.

(c) Questions which require candidates to describe substances in terms of particles may ask for descriptions of their arrangement, separation or their motion. Care should be taken to ensure that the correct property is being described in each case.

(d) The relationship between temperature, pressure and volume for a gas was not well understood or recalled. Some candidates described other effects of pressure such as on the rate of the reaction or described the motion of the particles.

Question 5

This question discriminated well between candidates.

(a) (i) Most candidates predicted a suitable melting point for rubidium.

(ii) Although a majority of candidates gave a suitable value for the solubility, fewer candidates answered this question correctly than for **(a)(i)**, which required a similar skill.

(iii) When given information describing a trend in observations, candidates should take care to match their answer to the information given. In this question, a statement which showed that the reaction was more vigorous than for sodium but less vigorous than rubidium was needed. Statements such as 'bubbles are seen' were insufficient.

(iv) Questions about physical state at a fixed temperature require answers of single physical state. Some candidates suggested more than one physical state or described a physical change. The reasoning given to justify the answer must always compare the stated temperature to the melting point and boiling point given in the question.

(b) (i) Although more sophisticated answers associated with oxidation state or electron movement are accepted, at Core level candidates are only expected to describe oxidation and reduction in terms of gain or loss of oxygen. A simple statement that the required substance has gained or lost oxygen is sufficient.

(ii) Only a minority of candidates recalled the term ‘redox’. Some candidates did not attempt this question at all.

(iii) Candidates who performed less well were most likely to give no response to this question. Many candidates recognised the word ‘thermal’ and described heating but did not describe the meaning of the term ‘decomposition’.

(c) (i) This question required a comparison between an alloy and a pure metal. Some candidates described a property common to both such as good conductivity or ‘they are strong’ rather than a statement describing a beneficial difference, such as strong<u>er</u> or more resistant to corrosion.

(ii) Recall of the metals present in brass and their atomic arrangement was not well recalled. Only a minority of candidates answered this correctly.

(d) Most candidates gained full credit for this question.

Question 6

Although some understanding was shown, candidates often gave a definitive answer rather than a comparative answer. For example, rather than stating that the reaction rate increased, they stated that the reaction was fast which does not describe how the reaction differs. Candidates must also be careful not to confuse reaction rate with reaction time.

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

(ii) One in five candidates did not attempt this question. The initial rate being shown as faster and so with a steeper gradient was the common answer for those that did attempt the question. Few candidates gained full credit.

(b) (i) The most common error was to give an answer that was not comparative such as ‘the reaction is fast’. Some candidates also confused rate with the time of reaction and stated that ‘less time would be taken’.

(ii) The effect of temperature on reaction rate was known by more candidates than the effect of surface area of a solid. This question was therefore answered correctly by more candidates than **(b)(i)**.

(c) This word equation was not well answered. Some candidates suggested ‘iron oxide’ as a product; ‘water’ was another common incorrect answer. Candidates should recall that the atoms and elements present in the reactants are the only atoms and elements present in the products.

(d) Few candidates gained full credit for this question. The most common correct answer was that the catalyst increases the rate of a chemical reaction.

Question 7

Organic chemistry is one of the most challenging topics and some candidates found this question rather challenging. It is recommended that candidates thoroughly practise writing all the syllabus reactions of the alkanes, alkenes, alcohols and carboxylic acids, as both symbol and word equations.

(a) (i) Over a third of candidates did not attempt this question. Incorrect answers included, circling the C=O group only, circling the O–H group of the carboxyl group only and circling the O–H of the separate hydroxyl group.

(ii) Candidates who performed less well either did not attempt the question or miscounted the atoms. Care should be taken when writing chemical formula that uppercase and lowercase letters are clearly and unambiguously shown and that numbers are written as subscripts. There should be no punctuation or other marks between the chemical symbols.

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

(ii) The test for unsaturation was not well recalled. A small number of the better responses suggested the correct test or observation, but few recalled both.

(iii) Only a small number of candidates could state meaning of the term polymer. Only the better performed candidates gained credit in this question.

(iv) The correct answer was the most commonly chosen option, but all of the other options were also selected by some candidates.

(c) Similarly to **6(c)**, many candidates tried to answer this by swapping chemical names around to produce answers such as 'ethanoic hydroxide' or 'ethanoic sodium'. Of those that identified sodium ethanoate, many did give the correct spelling.

(d) The products of combustion were not well recalled. Many incorrect answers such as 'carbon', 'nitrogen' or even 'sulfur' were suggested.

Question 8

This question was not well answered. Although most candidates could use the nuclide notation to determine the number of protons and neutrons present in an atom, the structure of an ion, the definition of ionic bonding and the products of the electrolysis of an ionic substance were poorly recalled or determined.

(a) Only a small number of candidates gained full credit. Many candidates described how an ionic bond was formed or described the bond commonly being between a metal and a non-metal but few described what the ionic bond is.

(b) Few candidates gained full credit for the dot-and-cross diagram of this common ion. Many candidates gave the electronic configuration for the lithium atom rather than the ion or gave an incorrect charge.

(c) Most candidates deduced the number of protons or neutrons; very few could give both.

(d) This question was not well answered. Some candidates were able to identify lithium as the product at the negative electrode; others reversed the two products at the two electrodes. Very few described the appearance of the bromine product. When describing the appearance of a chemical, candidates should give both its colour and the physical state.

(e)(i) A small number of candidates incorrectly suggested 'ionic bonding' or did not state the type of bonding and only gave the structure as 'giant'.

(ii) Very few candidates recalled the explanation of why graphite can act as a lubricant.

(iii) Most candidates correctly stated either 'jewellery' or 'cutting tools' as a use of diamond.

CHEMISTRY

Paper 0620/32
Paper 3 Theory (Core)

Key messages

- Candidates would benefit from learning the syllabus definitions of chemical terms and processes.
- Candidates should avoid restating information given in the question as their answer.
- Interpretation of data from tables and graphs was well done.
- The drawing of the dot-and-cross diagram was poor.

General comments

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

Questions on organic chemistry had the highest demand such as those in **Question 7**. The chemical terms 'unsaturated' in **Question 1(a)** and 'incomplete combustion' in **Question 3(b)(ii)** were not well known.

Candidates should take care that they are answering the question asked rather than making an assumption about the question. For example, in **Question 2(a)** candidates commonly described hydrocarbons rather than mixtures and in **Question 4(a)** candidates described particle arrangement rather than the general properties of a solid.

Chemical tests in **Question 3(c)(iii)** and **Question7(a)(iii)** were not well recalled. In **Question 6(c)(iii)** the indicator thymolphthalein appeared to be unfamiliar to many candidates.

Candidates are reminded that if asked to describe an observation such as in **Question 8(d)** the colour and state of the substance should be given, e.g. 'a green gas'.

Candidates showed good skill in extracting and using the data presented in **Questions 3(a)(i)–(iii), Questions 5(a)(i)–(iii), 5(d)** and **Question 6(a)(i)**.

Questions 2(b) and **6(a)(ii)**, which required candidates to add to or to complete a diagram or graph, were not attempted by a significant number of candidates.

Basic ideas of atomic structure were well known, and candidates could determine the numbers of particles present in an atom from the nuclide notation. Most candidates recalled the charge on a chloride ion, but few linked this to an increase in the number of electrons when completing the electronic configuration.

Questions requiring the completion of word or symbol equations are often good discriminators between candidates with those that perform less well, tending either to guess or to rely on reordering chemical names in reactants to produce a product name.

<u>Comments on specific questions</u>

Question 1

Many candidates found this first question challenging, although most candidates answered **(e)** and **(f)** correctly.

(a) Most candidates identified a hydrocarbon, although a significant number of candidates confused the terms ‘saturated’ and ‘unsaturated’ and gave methane or ethane.

(b) The deoxygenation of water was not well recalled. Sulfur dioxide and carbon monoxide were both more commonly chosen than either sodium phosphate or ammonia.

(c) Many candidates identified ammonia as the correct answer. Some confused the acidic nature of sulfur dioxide or suggested carbon monoxide.

(d) Most candidates incorrectly thought that carbon dioxide was the main constituent in natural gas.

(e) This question was well answered. A small number of candidates confused the reaction product with a reactant and chose carbon dioxide.

(f) This question discriminated well between candidates. Candidates who performed less well appeared to be guessing with any of the other options being suggested.

Question 2

The separation, properties and uses of petroleum fractions were not well understood. As a result, this was for many candidates the most challenging question on this paper.

(a) Many candidates assumed this question was about hydrocarbons rather than about a generic mixture. Many candidates answers described liquids or the presence of hydrogen and carbon. Some candidates described properties of hydrocarbons such as flammability or a use of hydrocarbons such as ‘as a fuel’. For those that described a mixture, many were ambiguous in describing the substance being ‘combined’, which could incorrectly mean chemically combined.

(b) (i) Fewer than half of the candidates attempted this question. Of those that did attempt the question, the most common response was to choose either the top of the fractionating column or the inlet for petroleum, both of which are incorrect. Where no answer line is provided, candidates should read the question carefully so that it is completed appropriately. Ticking off the mark, e.g. [1] at the end of the question when complete may help them to identify questions which they did not attempt.

(ii) Many candidates did not attempt this question. Candidates could consider learning a suitable mnemonic to help in the recall of the order of the fractions.

(iii) Where the fractions of petroleum show a trend in physical properties, the order of the trend will mirror the order of the fractions in the fractionating column. When predicting the lowest or highest boiling points, candidates should look at the fractions at the top and bottom of the column and consider the properties of those substances.

(iv) Few candidates identified a use for fuel oil. The most common answer was ‘fuel for cars’.

Question 3

This was the most accessible question on the paper. Nearly all candidates answered **(a)(ii)** correctly. In **(d)(ii)** the meaning of the ‘$\rightleftharpoons$’ symbol and in **(b)(i)** the adverse effect on health of particulates were well known.

(a) (i) Most candidates did not read the question carefully enough and so gave the pollutant with the highest concentration rather than the oxide with the highest concentration.

(ii) Most candidates answered this question correctly.

(iii) Only a minority of candidates calculated this value correctly. Common errors were to calculate '250÷28' or '250–28' or to divide by the wrong value, e.g. by 5 rather than 4.

(b) (i) Most candidates identified a correct adverse effect of particulates on health but some candidates gave answers which were too vague such as, 'they are harmful', 'they affect the lungs' or 'they cause death'.

(ii) This question was not well answered. Few candidates recalled that incomplete combustion requires a poor oxygen supply. Most candidates simply restated the question 'combustion that is not complete' or 'a reaction where not all the hydrocarbon is burned'.

(c) (i) Most candidates correctly identified the pH of an acidic solution.

(ii) The use of catalytic converters is new to the syllabus and was an unfamiliar term to many candidates. Many suggested that the correct term was an 'oxidising pump' or 'filter'.

(iii) This was one of the least well answered on this paper. Few candidates could recall either the aqueous solution or the metal required in the testing for nitrate ions. Many candidates suggested adding a nitrate.

(d) (i) Most candidates scored at least one of the marks in this question. Of those that did not score 2 marks, the most common error was to give '2O' rather than O_2 or to give 'NO_2' as a product.

(ii) Most candidates answered this question correctly.

Question 4

Most candidates were able to make suitable suggestions about the physical properties of a solid or to describe the arrangement of particles in a solid and a liquid. More care should be taken whether the question is requiring information about particles or not. Most candidates correctly identified the names for changes in physical states.

(a) Candidates should take note whether the question is asking for the general properties of a solid (or liquid or gas) or whether the question is asking about the arrangement of the particles within the substance. This question required candidates to describe the general properties of a solid and not the particle arrangement.

(b) Most candidates could correctly name both changes of physical state.

(c) Questions which require candidates to describes substances in terms of particles may ask for descriptions of their arrangement, separation or their motion. Care should be taken to ensure that the correct property is being described in each case. Many candidates described changes in state rather than the separation and motion of the particles in each stated physical state. Some candidates were confused by the word 'separation' and described separation processes such as filtration or distillation.

(d) The relationship between temperature, pressure and volume for a gas was not well understood or recalled. Some candidates described other effects of pressure such as on the rate of the reaction or described the motion of the particles.

Question 5

Candidates were able to handle the data presented in the table well and make suitable predictions for physical properties. Weaker responses did not describe reduction in **(b)(i)** or fully complete the equation for the thermal decomposition of calcium carbonate.

(a) (i) Most candidates suggested a suitable boiling point for sodium.

(ii) Most candidates suggested a suitable atomic volume for rubidium.

(iii) When given information describing a trend in observations, candidates should take care to match their answer to the information given. In this question a statement which showed that the reaction was less vigorous than for sodium was needed. Statements such as 'bubbles are seen' or 'a flame is observed' were insufficient.

(iv) Questions about physical state at a fixed temperature require answers of single physical state. Some candidates suggested more than one physical state or described a physical change. The reasoning given to justify the answer must always compare the stated temperature to the melting point and boiling point given in the question.

(b) (i) Although more sophisticated answers associated with oxidation state or electron movement are accepted where correct. However, candidates are only expected to describe oxidation and reduction in terms of oxygen gain or loss. A simple statement that the required substance has gained or lost oxygen is sufficient.

(ii) The use of Roman numerals to indicate oxidation number was not well known by the candidates.

(iii) This question discriminated well between candidates. Although many candidates identified either calcium oxide or carbon dioxide relatively few identified both. 'Calcium', 'carbon' or 'carbon monoxide' were commonly seen.

(c) (i) Most candidates identified the diagram which represented an alloy.

(ii) This question required a comparison between stainless steel and pure iron. Some candidates described a property common to both, such as 'good conductivity' or 'they are strong' rather than a statement describing a beneficial difference, such as 'strong<u>er'</u> or 'more resistant to corrosion'.

(d) Most candidates could order the four metals correctly.

Question 6

Candidates were able to use the graph in **(a)** to identify the volume of hydrogen, and many could describe the effect of changes in reaction conditions on the reaction rate. Parts **(a)(ii)**, **(b)(ii)** and **(c)(i)** discriminated well between candidates.

(a) (i) Most candidates deduced the correct volume from the graph. A small number of candidates mis-read the curve to give a value that was one unit too high or too low.

(ii) Almost one in five of the candidates did not attempt this question.

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

(ii) Most candidates answered this question correctly.

(c) (i) This word equation was not well answered. 'Hydrogen' was a common incorrect reaction product. Weaker responses were more likely to have rearranged names of the reactants to give answers such as 'lithium acid'.

(ii) Just over half of the candidates recognised the reaction of an acid with a hydroxide as neutralisation. All the other options were chosen.

(iii) Few candidates recalled the colour of thymolphthalein in an alkaline solution. Many confused the colours with those of methyl orange or with the colour of thymolphthalein in an acidic solution.

Question 7

These questions on organic chemistry were not well answered by the candidates who performed less well overall. Although **(b)** and **(d)(ii)** were well answered, the reactions of organic compounds were not well recalled.

(a) (i) Almost one in five of the candidates did not attempt this question. Many of those that did attempt the question chose either the C=C bond, the C=O bond of the carboxyl group or placed a ring around too many atoms.

(ii) Weaker responses either were blank or had a miscounted number of atoms. Care should be taken when writing chemical formula that uppercase and lowercase letters are clearly and unambiguously shown and that numbers are written as subscripts. There should be no punctuation or other marks between chemical symbols.

(iii) Many candidates knew one of the colours but few correctly deduced the colour of aqueous bromine both before and after reaction with fumaric acid. Some candidates suggested colours associated with acid-base indicators.

(b) Most candidates performed well here.

(c) Weaker responses identified either the water or the carbon dioxide only. Many of those who identified sodium ethanoate spelled the chemical name correctly, although there were a few close spellings such as 'ethanote'. Many candidates incorrectly suggested 'ethanol' as a reaction product.

(d) (i) Many candidates appeared to be confused by this question and described or named methods to make ethanol rather than suggesting a use for it. Some candidates repeated the question and stated 'to make ethanoic acid'.

(ii) Most candidates identified the correct general formula for the alcohol homologous series.

(iii) This question was not well answered. Many answers described fermentation rather than the catalytic addition of stem to ethene. Some answers were too vague such as 'pressure' or 'temperature' without suggesting whether these values should be high or low.

Question 8

The structure and properties of ions and ionic compounds were not well recalled. Although most candidates could identify the number of protons and neutrons in an atom from nuclide notation in **(c)(i)**, few could complete the diagram to show the electronic configuration of the ion in **(b)**. The determination and description of the products of electrolysis were not well answered.

(a) The properties of ionic compounds were not well recalled. Many candidates repeated the information given in the question. Other incorrect answers included 'low density', 'insoluble', 'non-metal' or a named ionic compound.

(b) This question was not well answered. A large majority of candidates gave the electronic configuration of a chlorine atom not of a chloride ion even if the correct charge was given. Some candidates showed only six electrons on the outer electron shell of the chloride ion.

(c) (i) Most candidates could determine either the number of protons or neutrons but not both.

(ii) Only a minority of candidates recalled the word 'cation' to identify a positive ion. Some candidates confused the term with 'anion', 'proton' or 'cathode'.

(d) Many candidates identified the production of zinc at the negative electrode. Fewer identified chlorine as the product at the positive electrode, often confusing it with chloride. Very few candidates identified the observations at the positive electrode. When describing the appearance of a chemical substance, candidates should give both its colour and its physical state.

(e) (i) Very few of the candidates who performed less well overall, answered this question correctly. The word ‘inert’ was not well known although descriptions of the inert nature of graphite were accepted. Some candidates mis-read the question and suggested other materials that could be used as an electrode.

(ii) Although a small majority of candidates correctly identified the structure and bonding in graphite, simple and covalent ionic were both commonly suggested.

(iii) Most candidates could recall a use for graphite with the ‘core of pencils’ and ‘lubricant’ being the most common answer. Some incorrect answers included ‘to make cars’, ‘in cracking’ and ‘kitchen surfaces’.

CHEMISTRY

Paper 0620/33
Paper 3 Theory (Core)

Key messages

- Questions where the candidate had to match the name of a substance to a 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 in **Question 7(d)**.
- Questions on the more detailed aspects of the kinetic particle theory were generally answered well. Some candidates still need to add more detail in their answers using the correct chemistry terms. There was also a tendency for candidates to get ‘arrangement’, ‘separation’ and ‘movement’ mixed up.
- Questions involving extended writing need to contain the same number of relevant points as the number of marks available. This should also be applied to any other question that has more than one mark available.
- 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 sulfate ions’ in **Question 3(d)(iii)**.
- Organic questions were answered well, and some candidates could draw the structures of organic compounds. Candidates struggled to ‘draw a circle around the functional group which reacts with aqueous bromine’ in **Question 7(c)(i).**
- Candidates struggled on some of the ‘uses’ type of questions, especially **Question 2(b)(iv)** which was to ‘State one use of the naphtha fraction’. More work on the recall of specific uses of substances detailed in this syllabus should be done with candidates.
- Candidates answered the graph question very well (**Question 6**). They were able to read off the graph the value that was needed. They could also draw the line on the graph to show the different condition stated.
- In **Question 8(c),** on the topic of electrolysis, many candidates could ‘State the names of the products at each electrode’. Candidates struggled with the ‘observations at the positive electrode’ and the definition for electrolysis.

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, in particular, the longer questions were poorly answered. Nearly all candidates were entered at the appropriate level but there were a few candidates who performed poorly. 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 4(c)** that asked 'Describe solid nitrogen and nitrogen gas in terms of the arrangement and separation of the particles'. Some candidates described separation of particles in a liquid instead. Many candidates thought that the 'separation' part of the question was to do with the separation of mixtures and put down 'fractional distillation' or 'filtration', whereas many other candidates talked about the 'movement' of particles instead of the 'arrangement' and 'separation' and gained no credit here. Another misinterpreted question was **Question 4(d)** where it asked, 'State how increasing the pressure affects the volume of nitrogen gas in the gas syringe when the temperature remains constant'. Lots of candidates answered this by stating how the particles of nitrogen gas moved or how they escaped from the gas syringe in this process. They did not mention anything about how the volume would change if the pressure was increased. Another misinterpretation was in **Question 8(e)(ii)** where candidates did not use the figure 'to explain why diamond is used in cutting tools'. They just wrote down their own information and did not use the figure as asked. The balancing of equations was good, demonstrating that candidates had practiced these as part of their revision. Definitions from across the syllabus were poorly answered. Candidates need to learn the definitions when the topic is being taught for the first time and revisit them during revision.

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

(a) Most candidates could answer this question correctly and knew that oxygen is a product of photosynthesis.

(b) Some candidates struggled with this and answered with 'ethane' or 'ethanol' instead of 'ethene'. More revision is needed on this part of the organic syllabus.

(c) Many candidates could not give the name of the substance that 'has an ion with a charge of 1–'. Lots of different incorrect answers from the list provided on this question paper were given here.

(d) There were not many correct answers seen for this question. Lots of different incorrect answers from the list provided on this question paper were given.

(e) Many candidates knew the correct answer. Weaker candidates incorrectly gave 'sulfuric acid' or 'ammonia'. More revision is needed on this part of the syllabus.

(f) Many candidates did not know that cobalt(II) chloride is used as a test for water. 'Calcium oxide' and 'sodium sulfate' were common incorrect answers here. 'Water' was also seen.

Question 2

(a) Candidates struggled with this 'State the meaning of' question. In this case, it was for a 'compound'. Some candidates could state that it contained 'atoms of two or more different elements' but then got mixed up with 'bonded' or 'chemically combined' and answered with 'are not bonded' or 'are not chemically combined'. Some candidates answered with the alternative correct point of 'cannot be separated' but many candidates mixed up the meaning of the term 'mixture' and answered with correct statements for a 'mixture' instead of a 'compound' as was asked in this question. The learning of definitions that are detailed in this syllabus is vital.

(b) (i) Many candidates left this question blank. Candidates must make sure that they attempt to answer every question on the paper. The **X** was meant to be drawn inside the lowest section of the column.

(ii) Not many correct answers were seen. Many candidates thought that the answer was 'petrol'. More revision and learning of the names of the fractions produced in the fractional distillation of petroleum is required.

(iii) Candidates struggled to name the appropriate fraction. Many candidates thought the answer was 'bitumen' which is the fraction with the longest chain. Revision of the trends in the properties of the fractions produced is needed.

(iv) Most candidates did not know 'one use of the naphtha fraction' and lots of incorrect answers were seen including 'fuel for cars' and 'fuel for large lorries'. More work on the recall of the specific uses of the substances detailed in this syllabus should be done.

Question 3

(a) (i) Candidates found this very straightforward and were able to easily look at the data and provide the correct answer.

(ii) This was answered very well.

(iii) This mathematical question was answered well and showed that candidates had practiced this type of question in their revision and practice of past papers. Some candidates did not show their working. Candidates must be encouraged to show their working when attempting questions like this as invariably when candidates do show their working out, they are more likely to get their answer correct.

(b) (i) Few correct answers were seen. Candidates must spend more time revising the sources of the pollutants named in this syllabus. Many candidates gave vague answers. Some candidates got mixed up with the sources of other pollutants named in this syllabus.

(ii) The effects of the different pollutants in the air were not recalled well by the candidates. Many candidates gave vague answers.

(iii) Candidates answered this question well.

(c) Most candidates answered this question well. Some candidates gave two answers and so had not read the question correctly.

(d) (i) Most candidates completed the symbol equation to a high standard. This showed that candidates had done much practice on these types of questions. There were a few instances where subscripts were not used.

(ii) This was another very well answered question.

(iii) 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.

Question 4

(a) Many candidates misinterpreted the rubric here and thought that the question was asking for answers about the 'particles' or 'molecules' of a gas and not as was asked in this question, 'State two general properties of a gas'. 'The particles are far apart' and 'the particles move very fast' were popular wrong answers. The question was asking for the 'general properties of a gas', such as 'does not have a definite shape' or 'does not have a definite volume'.

(b) Most candidates performed well on this question. A few candidates thought that the name of state change **B** was 'sublimation'.

(c) Candidates struggled with this kinetic particle model question. Some candidates got mixed up with the words ‘arrangement’ and ‘separation’ and used answers that would be correct for ‘movement’ instead. More practice is needed using these words. Other candidates answered with correct answers for a liquid and not for a solid or a gas as was asked in this question. More correct reading of the question was needed here. There were some candidates who thought that ‘separation’ meant the ‘separation of a mixture’ and answered the question using words like ‘fractional distillation’ and ‘filtration’. In general, more practice is needed in answering kinetic particle model type questions.

(d) Many candidates did not understand this question and totally ignored what would happen to the volume of nitrogen gas. They instead answered stating that ‘the particles of nitrogen gas would move more’ and that ‘the particles of nitrogen gas would escape from the syringe’. More practice of these types of questions is needed.

Question 5

(a) (i)(ii) Most candidates could answer these data handling questions demonstrating practice of this style of question from previous papers. They realised the trend in the melting point and atomic volume of the Group I metals and could therefore determine an appropriate melting point for rubidium and atomic volume for potassium. Some candidates answered with a range and one of their numbers was either too high or too low – these responses did not gain credit.

(iii) Many candidates did not use Table 5.1 and their own knowledge to work out the trend in the observations of the Group I metals with water and so could not give a correct answer for the observations of sodium. More practice on these types of questions is needed.

(iv) Most candidates could correctly write down the state of sodium but not give the correct reason. Candidates who performed poorly on the paper struggled to work out the physical state of sodium at the temperature given.

(b) (i) Many candidates did not know that the percentage of oxygen in clean, dry air is 21%. Many different very low and very high percentages were given here. This is a fact that candidates need to learn.

(ii) Many candidates selected the wrong answer demonstrating a lack of understanding of oxidation and reduction. Candidates are advised to use the equation given to state what is happening in terms of oxidation and reduction. More practice looking at equations and stating what has happened in terms of oxidation and reduction is required.

(iii) Some candidates could recall the definition of the term ‘exothermic’. Most candidates could state that it was ‘a reaction that transfers thermal energy’ or ‘a reaction that gives out heat’ but needed to include ‘to the surroundings’ to gain credit.

(c) (i) Many candidates found the naming of the type of chemical reaction shown in the equation particularly challenging and few correct answers were seen. Candidates did not use the information given in the equation to answer this question correctly.

(ii) Very few candidates knew that the correct answer was ‘slag’ or ‘calcium silicate’ with many leaving the answer line blank.

(d) This question was very well answered demonstrating that candidates had practiced these types of questions when revising. Some candidates got ‘copper’ and ‘cerium’ in the wrong order. Some candidates incorrectly thought that ‘metal’ was one of the correct answers.

Question 6

(a) (i) Most candidates could answer this question correctly and read off the graph how much oxygen was released after 15 seconds. Candidates who drew a line at 15 seconds and then allowed it to hit the curve and read off the volume from there performed well. Most candidates could do this, and it showed practice of this type of question using past paper resources. Few incorrect answers were seen.

(ii) Most candidates realised that the line would be less steep as the temperature was much lower than the first experiment, so the rate of reaction would be much slower. Most candidates knew that the line would start at (0,0) and then go to the right of the original line as it was much slower. Fewer candidates realised that the line would also level off at 46 cm^3 and it would get there much slower than the original line. Some candidates still need more practice on this type of question.

(b) (i) Many candidates knew that the rate of reaction would be much 'slower' when no catalyst is used. To gain credit, candidates' answers needed to be comparative. 'Slow' was insufficient. Some candidates incorrectly gave answers with respect to time. The question required an answer referring to the rate.

(ii) This question was answered poorly. Some candidates thought that the rate was 'faster', which was incorrect. Some candidates used the word 'slow' in their answer instead of the comparative 'slower'. This question also did not ask for a reference to 'time', which some candidates quoted.

(c) (i) Very few candidates gained credit here. They did not know that an alkali is a soluble base. Many different wrong answers were seen, such as neutralisation general equations.

(ii) Most candidates did not know the correct formula of the ion present in all alkaline solutions. Many candidates wrote down a general formula from organic chemistry such as for alkanes or alkenes. Others wrote down 'H^+' and so got mixed up between this question asking for an alkaline solution and their answer which was for an acidic solution.

(iii) Some candidates answered correctly. A variety of incorrect colours were stated by many candidates. Candidates should revise the correct colours of the indicators stated in the syllabus in both acidic and alkaline conditions.

(iv) Some candidates answered correctly. Other candidates incorrectly answered 'ammonia chloride' or 'ammonia hydrochloric acid'. More practice on this type of word equation is needed.

Question 7

(a) Many candidates got the spelling of the salt incorrect and did not know that the other product in this word equation was 'hydrogen'. Many thought it was 'water'.

(b) (i) Some candidates knew the correct homologous series. Other candidates just named another alcohol in this series, such as 'methanol'. These candidates did not know what the term 'homologous series' meant.

(ii) Many candidates did not know two of the conditions for fermentation. Many got the 'fermentation' manufacturing process mixed up with the 'addition of steam to ethene' manufacturing process and answered with the correct two conditions for this process instead.

(c) (i) This question was very poorly answered. There were also a lot of 'no responses' seen. Many candidates drew a circle around the carboxylic acid functional group instead of around the carbon–carbon double bond.

(ii) Most candidates knew the correct colour. Candidates should be discouraged from using two colours in their answer with a hyphen between them because sometimes one of the colours may be wrong. It is much better to use only one colour in their answer.

(iii) Candidates did well on this question. A few candidates used superscript instead of subscript.

(d) This was a very well answered question by most of the candidates. Some candidates did not realise that there were eight hydrogens and two oxygens in the given formula and just used one of each in their calculation.

(e) Some candidates could write down one correct answer but not two. Many candidates gave answers that were too vague. For example, 'pollutes the oceans' and 'water pollution'. Candidates need to do more revision for these types of environmental questions.

(f) Many candidates could not identify the correct monomer with many drawing ethane or propane instead of ethene. Some candidates who correctly drew ethene added trailing bonds to each carbon making each carbon atom have five bonds around it, which was then incorrect. More practice is needed on this topic in the organic part of this syllabus.

Question 8

(a) Most candidates could complete the figure to show the correct electronic configuration of a potassium ion using either dots or crosses for the electrons. Some candidates thought that the configuration was 2,8,7 and did not draw enough dots or crosses on the figure. A few candidates drew on an extra shell and put one electron on it as they incorrectly thought that this was the element. Some candidates did not know the correct charge. The most popular wrong answer here was '1–'.

(b) Candidates did very well on this question. A few candidates incorrectly thought that either the number of protons or neutrons was 18. They got mixed up with the charge given on the ion and the number of electrons.

(c) (i) Candidates struggled with this definition question. Some candidates were able to state, 'by an electric current' or 'by electricity' but very few commented on the 'breaking down of an ionic compound' or 'decomposition of an ionic compound'. More revision is needed on this definition and on all definitions stated in this syllabus.

(ii) This question was answered poorly. Many candidates got the products mixed up or incorrectly thought that 'chloride' was given off instead of 'chlorine'. There were candidates that did not understand this question at all and wrote answers that had nothing to do with the question or the electrolysis topic. There were only a few candidates that knew the observations at the positive electrode. More practice is needed to predict the products of the electrolysis of molten compounds.

(d) Few correct answers were seen. Candidates did not know the name of another 'inert electrode' as well as the mentioned 'graphite'. Lots of different incorrect answers were seen including more reactive metals such as 'copper' and 'lead'.

(e) (i) Many candidates could correctly identify the type of bonding present. A few candidates thought that the answer was 'ionic'.

(ii) This was poorly answered. Many candidates wrote down 'it was hard' but could not use the figure shown to say why diamond is used in cutting tools. They needed to state that diamond was a 'giant structure and hard' or it had 'strong bonds and was hard' or it had 'many bonds and was hard'. Candidates need to make sure that they read the question carefully and use the diagram as instructed. Many did not use the diagram.

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Paper 0620/41
Paper 4 Theory (Extended)

Key messages

- Ionic equations, including half-equations, continue to be an area that needs considerable improvement, especially those concerning halogen displacement.
- Some candidates need more familiarity with answering questions based on the greenhouse effect, oxidation number and equilibria.
- Mole calculations remain a challenge for many candidates, and they would benefit from further practice at calculations involving moles of gases, Avogadro's number, and relative atomic mass.

General comments

Candidates appeared to have sufficient time for all questions to be answered, although it was common for candidates not to attempt some parts of the paper.

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

Comments on specific questions

Question 1

(a) This question was answered well with most candidates choosing sulfur dioxide as the gas that causes acid rain. A few candidates chose carbon dioxide or carbon monoxide.

(b) Fewer candidates answered this well. A common error was to choose fluorine rather than ammonia.

(c) Most candidates knew that xenon was a noble gas.

(d) Most candidates knew that oxygen was the product of photosynthesis. The most common error was carbon dioxide.

(e) The majority of candidates were able to recall that ethene can form a polymer.

(f) This question was answered well. Many candidates were able to recall that ammonia was produced in the test for nitrate ions.

Question 2

(a) This question was answered well. Most candidates were able to find the number of protons, neutrons, and electrons in an atom.

(b) (i) The understanding of the definition that relative atomic mass is the average mass of isotopes, was tested in this question. Candidates found this challenging. Candidates were expected to realise that if an element with a relative atomic mass of 10.8 consisting of two isotopes, one weighing 10 and the other weighing 11, each isotope must be present as 20% and 80% of the atoms respectively. Very few candidates gave the correct response of 20%.

(ii) Candidates were being tested on the use of Avogadro's number to calculate the number of atoms in a known mass of boron. Many candidates were able to calculate the number of moles of boron but were then unable to use this value to calculate the actual number of atoms. A significant number of candidates used a value for Avogadro other than the syllabus value and thus did not gain credit. The syllabus value of 6.02×10^{23} should be used for these types of calculations. A common error was to use the relative molecular mass of just the heaviest isotope, ^{11}B, rather than use the relative molecular mass of 10.8 given in the question.

(c) (i) Most candidates were able to recall that bauxite was the aluminium ore.

(ii) While most candidates were able to recall that cryolite was used in the electrolysis of aluminium, the reason for its use was less well answered. Common errors included to lower the melting point of aluminium, to act as a catalyst or to lower the activation energy.

(iii) Many candidates gave a fully correct equation. Some candidates put the incorrect charge on the aluminium ion, and some put Al^0 on the product – this is not necessary or a conventional notation on ionic half equations.

(iv) The need for anode replacement was not well known by most candidates. Responses were very vague, using terms such as 'they are consumed', 'they disintegrate', 'they dissolve' or 'they get covered in aluminium'. Very few candidates referred to the chemical process of the carbon anode reacting with the oxygen produced.

(d) While this question was answered well by most candidates, some candidates confused physical and chemical properties and answered in terms of their chemical reactivity such as, resistant to corrosion or unreactive. A few candidates confused low density for lightweight which is not the same property.

(e) Most candidates could not recall that aluminium has an unreactive oxide layer and tried to explain the lack of reactivity in terms of electronic structure and the fact that aluminium could lose 3 outer electrons.

(f) (i) The formula of fluorine was not well known. Candidates need to be aware of the diatomic elements on the Periodic Table. Common equations seen were $Al + 3F \rightarrow AlF_3$ or $Al + F_3 \rightarrow AlF_3$. Very few candidates gained any credit here. Some candidates attempted an ionic equation when the question asked for a symbol equation.

(ii) This question was not answered well. Many candidates drew the electronic configuration of the atoms rather than the ions. A few candidates only put the charges on the ions and did not attempt to draw additional electron shells. Some candidates had the correct idea for the electronic configuration but did not recognise the importance of following the guidance given in the diagrams, which showed it was necessary to use crosses for aluminium and dots for fluorine. The ionic charges were usually correct, although the answer was also seen reversed with Al^{3-} and F^{+}. It is important for candidates to check that ions have a full outer shell of electrons, and this should help them draw these diagrams more accurately.

Question 3

(a) (i) A significant number of candidates did not complete the table or gave incorrect responses. Candidates are encouraged to use the data given to them to help them complete this application task. Only those candidates that successfully completed the table usually gave the metals in the correct order.

(ii) The candidates found this question difficult with the most common error being to think nitrates were more reactive than sulfates. Some simply stated that not all sulfates are soluble without relating their response to the sulfates given in the question.

(iii) The candidates found this very hard as most were unable to find the formula of zinc nitrate. Most candidates thought the formula was $ZnNO_3$. The candidates that did get the correct formula of $Zn(NO_3)_2$ often did not balance the equation. Very few candidates gained full credit.

(b) (i) Most candidates realised there was a colour change with bromine but confused it with the test for alkenes and put orange to colourless as opposed to colourless to orange. A number of candidates thought the starting colour was red or red-brown.

(ii) Candidates found this ionic equation very difficult and very few candidates gained any credit. The candidates that attempted this question usually put the chemical formula, e.g. KCl. The state symbol mark was often not awarded as candidates thought that the Br_2 at the end of the reaction was (g) as opposed to (aq). Care should be taken when writing state symbols, e.g., Aq, G, aQ are all incorrect representations.

(iii) This was done well with most candidates realising that reactivity decreases down Group VII and therefore choosing tennessine, Ts.

Question 4

(a) The test for oxygen was well known. Common mistakes included ‘splint relights’, ‘blown out splint relights’, ‘wooden stick relights’ or ‘burning splint that has gone out’ without the idea that the splint is glowing.

(b) (i) Candidates had a good understanding that a lower gradient shows a lower rate of reaction.

(ii) It was very common for candidates to ignore the question remit and instead chose to describe the more familiar scenario of how an increase in concentration affects the rate of reaction.

The most common error for those who didn’t state the concentration decreases, was to state that there are ‘fewer particles’ rather than ‘fewer particles in the same volume.’ Many wrote ‘there are fewer collisions’ rather than stating that the ‘frequency of collisions decreases’. Several candidates thought that energy decreases as concentration decreases.

(iii) Most candidates were able to sketch a steeper line finishing at the same volume. It is important to note that the steeper line should level off sooner than the original graph line and that the line should be one smooth line starting at the origin.

(c) Many candidates found this calculation challenging. Often the use of $24\,000\,cm^3$ was omitted in the calculation but then candidates did realise there was a 1 : 2 mole ratio; although some divided their first number of moles by 2 rather than doubling it. Candidates were much better at calculating the concentration and most were able to do this even if their original number of moles were incorrect. Most candidates were unable to calculate the correct relative molecular mass for hydrogen peroxide. The most common incorrect relative molecular mass was 68 or 17.

(d) Most candidates could name a transition metal oxide that could be used as a catalyst. A number incorrectly thought that aluminium was a transition metal.

Question 5

(a) Candidates found this question on equilibria demanding. Many candidates only offered the idea of an equilibrium being a ‘reversible reaction’ or a vague idea of ‘balance’ but did not write anything to acquire credit. Examples of loose wording include ‘forward reaction equals backward reaction’ (no mention of rate) and ‘concentrations of reactants and products are the same’; what should have been written was ‘concentrations of reactants and products remain the same’ or ‘concentrations of reactants and products remain constant’.

(b) (i) Candidates should be familiar with questions that ask for an explanation of the position of equilibrium following a change in conditions. Better performing candidates stated if pressure is increased:

- the position of equilibrium shifts or moves to the left-hand side
- to the side with fewer gaseous moles
- so, concentration decreases.

(ii) Good answers stated that if temperature is increased:

- the forward reaction is endothermic
- therefore, the position of equilibrium shifts or moves to the right-hand side
- so, concentration increases.

There were many references to the equilibrium breaking and that the reaction would go forward. As equilibrium reactions are reversible, candidates need to say that the position of equilibrium 'moves or shifts forwards' rather than 'goes forwards'. Candidates should be aware that there is no such thing as an 'endothermic side' to a reaction; there is, however, an endothermic direction.

(iii) More of the candidates were able to recognise that a catalyst only speeds up the reaction and does not influence the position of equilibrium.

(c) (i) Most candidates could state that carbon dioxide was a greenhouse gas. A few candidates incorrectly stated that carbon monoxide was a greenhouse gas. It should be noted that water vapour is not found in clean *dry* air.

(ii) The candidates found this extremely difficult, highlighting many misconceptions about global warming. There was a lot of confusion about the greenhouse gases and their impact on the ozone layer or indeed that greenhouse gases make up the ozone layer or make the ozone layer thicker. Other candidates thought that greenhouse gases created the thermal energy or absorb thermal energy directly from the sun. Candidates are advised to prepare answers based around this new syllabus content:

- Thermal energy from the sun is absorbed by the Earth's surface.
- The Earth reflects thermal energy.
- Greenhouse gases absorb the thermal energy and reduces thermal energy loss.

Question 6

(a) Conditions for the fermentation of aqueous glucose were not well known and many incorrect responses included the use of sunlight and/or oxygen. More candidates knew yeast was necessary, but few had the idea of anaerobic conditions.

(b) (i) The temperature and pressure for the addition of steam to ethene was not well known. Very few candidates knew the correct conditions of 300 °C or 600 kPa with many quoting figures from other industrial processes such as the Haber process.

(ii) Ethene was the correct answer given by most candidates, so this was answered well.

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

(c) (i) While many candidates could recall that an acid is a proton donor many others simply stated that an acid has a low pH or a pH lower than 7. Some candidates wrote that H^+ ions are released or produced which is not the definition of an acid.

(ii) Candidates often just quoted that a weak acid has less H^+ ions or a pH of 4 to 5 rather than realising that the acid had only partially dissociated.

(iii) This question was found to be very demanding for candidates and the majority found the concept of oxidation number challenging. A common answer was simply to state –3 as the charge on the ion. Better performing candidates were able to see that overall, the oxygen would have a charge of –8 so P must be +5. It should be noted that it is best practice to quote an oxidation state as +5 and not 5+ or +V.

(d) Most candidates were able to state that addition of ethene was faster than fermentation. Candidates who performed less well could not state an advantage of fermentation over addition of ethene, with many simply stating it was renewable rather than uses renewable resources.

(e) (i) The oxidising agent was not well known by most candidates. Common incorrect examples included methanoic acid, oxygen, water, carbon monoxide and sulfuric acid.

(ii) Most candidates were able to state ethanol was the reducing agent.

(f) (i) Candidates were able to name the calcium salt with a high degree of accuracy and this question was well answered.

(ii) Most candidates were unable to write the formula of calcium ethanoate with only a few correct answers seen.

(iii) Most candidates were able to state the other product from a metal and acid reaction was hydrogen. The most common error was water.

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Paper 0620/42
Paper 4 Theory (Extended)

Key messages

- Candidates should not use charges with formulae in chemical equations and should take care over the use of capital or lower-case letters and use of subscript. The following were all examples of the formula of lead(II) chloride, $PbCl_2$, which did not receive credit: $Pb^{2+}Cl_2$, PbC*l* 2, $PBCl_2$, $pbCl_2$.
- Candidates should not provide fractions as answers to calculations.
- If one answer is required, candidates should refrain from giving more than one response.

General comments

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

Some candidates overwrote changes to their responses which can make them difficult to credit, particularly if they are similar letters or numbers. To cross out and replace would ensure candidate's work is visible.

Many definitions and terms introduced into the new 2023 syllabus were not known.

Comments on specific questions

Question 1

Candidates performed well, apart from **(g)** where only about a quarter of the candidates knew that electronic configuration **B** (2,8) was that of an **ion** of a Group V element. Most selected **A** (2,5) or **E** (2,8,5), which were both electronic configurations of Group V **atoms**.

Only the letters representing electronic configurations were required, however, a significant number unnecessarily tried to repeat the electronic configuration or attempted to name the species.

Question 2

(a) (i) Candidates performed well on this question – the most common error being to give the Cu^{2+} ion two more electrons than the number of protons.

(ii) Most candidates multiplied each isotopic mass by the relative abundance, added these values then divided by the total relative abundance.

Some went on to give the answer as a whole number value rather than an answer to one decimal place as asked in the question.

(b) Most candidates gave the expected responses of melting point and density. Some candidates stated 'hardness' but this was given in the question so received no credit. By far the most common error was to give differences in **chemical** properties such as: catalytic activity, formation of coloured compounds and, occasionally, variable oxidation number.

(c) (i) Although the concept was understood, the syllabus definition of water of crystallisation was not known. Common answers that were insufficient included ‘water inside crystals’ or ‘water needed to make crystals’.

(ii) The pink colour of hydrated cobalt(II) chloride was quite well known. Higher performing candidates gave the correct formula, $CoCl_2.6H_2O$. Candidates who performed less well omitted waters of crystallisation completely or wrote $CoCl_2.5H_2O$, presumably because of confusion with $CuSO_4.5H_2O$.

(iii) The colour change when water is added to anhydrous copper(II) sulfate was well known.

(iv) Most knew that water was needed to be removed from hydrated copper(II) sulfate but many did not state that heating was needed to accomplish this. Vague responses such as, ‘remove the water’ or ‘evaporate the water’ achieved no credit.

Question 3

(a) Only the better performing candidates wrote ‘hot air’. Other candidates thought that carbon (or even carbon dioxide) was the other starting material. One common incorrect response was ‘oxygen’. Although oxygen is part of air, it is air that is the starting material.

(b) (i) ‘Hematite’ was known by many candidates as the main ore which contains Fe_2O_3. ‘Bauxite’ was the common error seen from some candidates.

(ii) Most candidates balanced the equation successfully.

(iii) Many candidates did not realise that, unless zero, oxidation numbers need a ‘+’ (or ‘–’, if applicable) before the integer. So ‘3’ for the oxidation number of Fe in Fe_2O_3 received no credit. The expected answer was +3. Candidates who performed less well gave incorrect responses, such as Fe^{3+} and Fe(III).

(iv) The reduction of iron in terms of change in oxidation number being a decrease in this reaction was poorly answered. Many candidates simply relied upon the acronym ‘OILRIG’ and stated ‘iron lost electrons’. Others looked at the equation and stated that ‘iron lost oxygen’.

(c) Only the better performing candidates knew the relevant equations.

Equation 1, $CaCO_3 \rightarrow CaO + CO_2$, was better known than equation 2, $CaO + SiO_2 \rightarrow CaSiO_3$.

The reaction type for equation 1, thermal decomposition, was better known than that of equation 2 which needed candidates to realise it involved a metal oxide reacting with a non-metal oxide, so was an acid-base reaction. Most gave the acceptable alternative of ‘neutralisation’.

(d) (i) The correct term, ‘alloy’, was well known, although many thought the term was ‘compound’.

(ii) Some candidates were aware that the syllabus describes stainless steel as a mixture of iron and other elements such as chromium, nickel, and carbon, so the one element other than carbon in the making of stainless steel was likely to be chromium or nickel.

(e) Very few gave the answer ‘hydrated iron(III) oxide’.

(f) (i) Relatively few knew that coating steel with zinc is ‘galvanising’.

(ii) Most opted for ‘painting’ or ‘oiling’ as another barrier method.

(iii) Although better performing candidates answered correctly based upon zinc’s higher reactivity than iron and therefore reacting in preference to iron, many others assumed zinc acted as a barrier throughout the process.

Question 4

(a) (i) Better performing candidates gained full credit but many other candidates were not able to identify the two soluble salts based on the general solubility rules for salts in the syllabus.

To make lead(II) chloride, the soluble lead salt should have been lead(II) nitrate and the soluble chloride should have been, for instance, sodium chloride.

(ii) Some candidates struggle with ionic equations for precipitate formation. Such equations will always have two reactant *ions* and one product compound. In this question, the formula of the product compound, $PbCl_2$, was given. The sequence of state symbols will always be (aq) + (aq) → (s).

Errors were to only have one Cl^-(aq) ion as a reactant ion and other candidates attempted to write the complete symbol equation, usually unsuccessfully.

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

(iii) Better performing candidates gave the three key points needed in the preparation of an insoluble salt from a reaction mixture: filtration; rinsing; drying. Many other candidates were confused by the practical nature of what was required.

Some candidates suggested heating the mixture, which contained a precipitate, to the crystallisation point and gained no credit. Others described how to prepare crystals from the filtrate and suggested filtration but went on to heat (presumably the filtrate) to the crystallisation point.

Many candidates are unsure of the meaning of residue and filtrate. Often responses would state, after filtration, 'rinse the filtrate then dry the filtrate'.

(b) (i) Better performing candidates knew that lead(II) chloride needed to be molten so ions would become mobile. Most candidates incorrectly stated it was electrons that needed to become mobile.

(ii) Candidates need to learn that during electrolysis negative ions are attracted to the anode and upon reaching the anode, they lose electrons. This would have helped them to write the ionic half-equation.

(iii) The test for chlorine gas was not very well known. Random gas tests were given e.g., 'glowing splint' and 'relights a splint'. Another common error was to add silver nitrate – an obvious confusion with the chloride ion test.

(iv) Candidates struggled to understand that 'Describe what is observed…' essentially means 'What would you see...'. Descriptions such as these need a colour (in this case grey) and a state. Thus, answers such as 'lead forms' did not receive credit, neither did 'solid forms' nor 'lead is deposited'.

Question 5

(a) Enthalpy change was not known by most candidates.

(b) (i) Candidates were not able to explain answers in terms of collision theory with great success. Many candidates omitted that rate of reaction increases.

Very few related the increase in rate of reaction to more particles per unit volume. A significant number correctly stated that the *frequency* of collisions (not just 'more collisions') of particles increases, but many of these candidates went on to incorrectly state that at higher concentrations the energy of the particles increased, or the activation energy changed.

(ii) Although some well-expressed answers were seen, many other candidates did not address the key focus of the question about *equilibrium*. Candidates need to be taught that it is the *equilibrium* which shifts and **not** the reaction. The reason for the shift in equilibrium should then be given. Many candidates struggled with their words and gave very unclear answers. There was some confusion between left and right with some candidates, as well as contradictory statements such as 'the equilibrium shifts towards the reactants' followed later by 'the equilibrium shifts to the right-hand side'.

Many irrelevant comments about rate of reaction change were also seen.

(iii) Many candidates drew arrows which did not originate from an energy value horizontal from that of the reactants and:

- did not reach the peak of the activation energy 'hump' for E_a
- did not reach an energy value equivalent to that of the products for ΔH.

The direction of each arrow is important. E_a should be indicated by an upwardly headed arrow and ΔH by a downwardly headed arrow. Double headed arrows are incorrect as they do not indicate the endothermic/exothermic nature of the change.

(iv) The definition of activation energy is new to the syllabus. Many candidates wrote 'minimum energy to start a reaction' but only a few attempted to define activation energy in terms of colliding particles reacting.

(v) Although the majority knew that adding (or removing) a catalyst would change the activation energy, many incorrectly thought that changing the temperature would alter the activation energy.

(c) Candidates were confident in performing the two calculations involving bond energies and the answers 3200 kJ and 1610 kJ were frequently seen.

Common errors were:

- Omitting two O–H bonds and arriving at a value of 2280 kJ for the first answer.
- Misreading the question and adding the ΔH value of 130 kJ to 1610 kJ to give 1740 kJ.
- Many candidates were unable to incorporate the ΔH value of 130 kJ correctly into their calculation to find the total H–Cl bond energy.

Question 6

(a) Many candidates performed well. Some candidates repeated a phrase from the question in their answer which stated '… members have similar chemical properties'. This approach is unlikely to gain credit.

(b) Relatively few candidates knew the difference was a $–CH_2–$ unit.

(c) (i) Most candidates performed well here, and all three homologous series were known.

(ii) The name, propanoic acid, was well known. Candidates should be aware that spelling is important for organic chemicals. Propenoic acid suggests the presence of an alkene group. Candidates are also expected to show every atom and every bond in a displayed formula. Frequently, the –O–H bond was left as –OH.

(d) (i) Many candidates found this question challenging and did not know how to approach it. Addition of the relative atomic masses was not done in a systematic manner and atoms were omitted. Sometimes atomic numbers were used instead. Often only a numerical answer was given without a formula being attempted.

(ii) Most candidates knew the name given to natural polyamides was proteins.

CHEMISTRY

Paper 0620/43
Theory (Extended)

Key messages

- Several responses asked for names of chemical substances. Some candidates chose to give formulae instead of names.

General comments

Candidates have found it difficult to answer questions that ask to state observations or to say what they would see when an experiment is performed. It is not necessary to give names of substances when answering such questions. Points that should be essential parts of the answers to such questions are:

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

Candidates should learn how to calculate oxidation numbers and to define oxidation and reduction in terms of oxidation numbers.

Candidates should know the differences between general formulae, molecular formulae, empirical formulae, structural formulae and displayed formulae.

Comments on specific questions

Question 1

(a) This was usually answered correctly. Sodium bromide was occasionally seen as the wrong answer.

(b) This was answered much less well. Barium nitrate and potassium iodide were the most common wrong answers.

(c) This was answered quite well. Oxides other than sulfur dioxide were seen occasionally. A few answers were substances other than oxides.

(d) This was answered quite well. Ethane was the most common error.

(e) This was usually answered correctly.

(f) This was often answered correctly. Hydrated cobalt(II) chloride was the most common error.

Question 2

(a) (i) All six particles were occasionally seen as the answer. Some candidates assumed there was only one particle that fitted the criterion.

(ii) This was usually correct.

(iii) This was often correct.

(b) This was answered quite well. Occasionally, 11 was seen.

(c) This was answered well. Many possible additions of 16, 17 and 18, such as 34 and 35 were seen.

(d) Most candidates answered this correctly. The most common incorrect answer was 2,8,6. Presumably the candidates who gave this used 16 instead of 18.

(e) This was almost always correct.

(f) This was usually correct. Sometimes 1 or 3 were given. Roman numerals were seen occasionally.

Question 3

(a) (i) This was usually correct. Occasionally, 70 or 71 were seen.

(ii) Air as a source of hydrogen was seen occasionally. Some candidates referred to incorrect processes by which hydrogen was manufactured.

(iii) Some candidates only had one non-bonding electron instead of two. Eight electrons on the outer shells of the hydrogen atoms were seen occasionally.

(iv) The most common error was to omit the equilibrium sign from the equation.
$2N + 3H_2 \rightarrow 2NH_3$ was seen occasionally. Having completed the dot cross diagram of ammonia in **(a)(iii)** some candidates could not go on to write the formula NH_3 correctly.

Vanadium(V) oxide was occasionally seen as the catalyst. Temperature and pressure occasionally had units missing.

(b) (i) This was left blank quite often, perhaps because candidates did not see the question.

(ii) Only a minority of candidates answered this correctly. Many candidates gave answers that were other than oxidation numbers such as –**III**, N^{3-} and N^{2+}.

(iii) Only a minority of candidates answered this correctly. Very few answers referred to oxidation numbers. The most common approaches referred to transfer of electrons or oxygen.

(iv) This was answered reasonably well.

(v) ‘Decrease in kinetic energy’ or ‘molecules moving slower’ were seen often. ‘Particles gain less energy’ was occasionally seen as a wrong answer. Those who mentioned collisions sometimes omitted to refer to frequency of collisions. Activation energy was rarely referred to. Some candidates suggested that activation energy is dependent upon the energy of a particle and therefore decreased when energy decreased.

Comparative statements were required for all three marking points.

(c) This was answered reasonably well.

Question 4

(a) (i) Most candidates answered this correctly. Zinc was the most common wrong answer.

(ii) Only a small number of candidates answered this correctly. Observations were only referred to occasionally. ‘Zinc not dissolving’, ‘gas not given off’ and ‘sulfuric acid reacting completely’ were amongst several answers that received no credit. Some candidates misread the question and answered as if asked ‘how do we know a reaction happens’. Therefore, they wrote ‘fizzing’ or ‘solid dissolves’.

(iii) This was answered reasonably well. Zinc and sulfuric acid were the most common wrong answers. There was confusion between filtrate and residue. Some gave answers that related to the process e.g. ‘filter paper’ rather than the name of a substance.

(iv) This was answered reasonably well. Salts such as zinc chloride and zinc nitrate were seen occasionally. Some substances other than zinc compounds were seen.

(b) (i) Candidates are advised to learn the meaning of the term saturated solution. Many answers made no sense. The terms solute, solvent and solution were frequently used interchangeably or incorrectly.

(ii) Only a minority of candidates answered this correctly. It was often suggested that cooling caused evaporation of the water from the solution leaving crystals behind.

(c) (i) Only a few candidates answered this correctly. Hydrous, saturated, aqueous and anhydrous were common incorrect answers.

(ii) Only a few candidates answered this correctly. Candidates were expected to make it clear than heating until there is no change in mass would ensure that **all** the water had been removed from the crystals.

(iii) This was answered well. However, some candidates were unable to evaluate the number of moles of water.

Question 5

(a) (i) Many candidates described ionic bonding instead of metallic bonding. Protons or nuclei were occasionally named instead of positive ions. Some candidates referred to ‘attraction between positive ions’ or ‘attraction between positive ions and negative ions’. Some candidates referred to ‘forces’ or ‘electrostatic’ or even ‘electrostatic forces’ without mentioning attraction.

(ii) Only a few candidates answered this correctly. The incorrect term ‘free’ was regularly used by candidates when describing electrons; it has no meaning in this context. It was essential to describe the electrons as moving. ‘Sea of electrons’ or ‘delocalised electrons’ had to be qualified by reference to movement of electrons.

(b) (i) This was often incorrect. Some candidates seemed to confuse the addition of coke with the addition of cryolite in the extraction of aluminium. It was not uncommon to see ‘catalyst’ as the answer or reference to removal of impurities. There were occasional references to the formation of slag. Production of heat was rarely mentioned.

(ii) Only a minority of candidates answered this correctly. It was common to see answers that suggested that limestone was involved in reactions that produced iron. Decomposition of limestone into calcium oxide was often omitted from the answer. Silicon(IV) oxide was often missing. A common answer that did not gain credit was that limestone reacts with unspecified impurities to produce slag.

(iii) The formula of iron(III) oxide was frequently incorrect, often given as Fe_3O_2. Oxygen was occasionally seen as a reactant or as a product. It was common to see iron(III) oxide decomposing instead of being reduced.

(iv) Most answers only suggested that the heat melts the iron without any further information. Very few candidates referred to the melting point of iron (or the temperature at which iron melts). Some candidates mentioned that having iron molten was convenient. A recurring response was that there was no water in the furnace.

(c) Many candidates knew that atoms were different sizes and showed this in a diagram but often did not state that the particles were atoms or that the circles represented particles. Very few candidates referred to atoms or ions in the alloy structure. Diagrams were usually unlabelled. Reference to layers was also often omitted.

(d) (i) Air was often seen instead of oxygen. It was common to see one substance given instead of two.

(ii) Electroplating was a common answer. Sacrificial protection was also commonly seen. The question required a name that was exclusive to zinc.

(iii) Many answers suggested that the method depended on difference in reactivity as opposed to a barrier that prevented oxygen and water reaching the zinc.

(iv) Some answers would have gained credit for **(d)(iii)**. Many candidates suggested that zinc reacts and forms a barrier.

Question 6

(a) This was answered well. Same molecular formula, empirical formula or structural formula were seen occasionally.

(b) ‘Ethyl ethanoate’ was occasionally seen. Presumably this was because some candidates did not include the carbon atom in the ester group. ‘Propyl ethanoate’ was also seen occasionally.

(c) (i) Very few candidates identified the alcohol correctly. ‘Propanol’ was far more common than ‘propan-1-ol’. ‘Methanol’ and ‘propanoic acid’ were seen occasionally.

(ii) Some candidates attempted a structural formula.

(d) This was usually correct.

(e) (i) ‘Addition’ was the most common incorrect answer.

(ii) The O–H bond was occasionally missing in the dicarboxylic acid. The dialdehyde was a common wrong answer for the dicarboxylic acid. Monomers were occasionally drawn with trailing bonds. Some candidates drew parts of the polymer chain as opposed to monomers.

(f) (i) Polymers and monomers in **(f)(i)** and **(ii)** were often confused.
Nylon was seen occasionally. Carbohydrates, starch, polyamides and natural polymer were fairly common.

(ii) Glucose was seen occasionally. Carbohydrates, starch and natural polymer were fairly common.

CHEMISTRY

Paper 0620/52
Paper 5 Practical Test

Key messages

- The Confidential Instructions state that the supervisor must do the experiments in **Questions 1** and **2** and record the results on a copy of the Question Paper. It is important that the supervisor records the actual results obtained and **not** just the expected results. The expected results are already known, however, problems with the purity of substances can cause issues with experimental results, especially in the qualitative task (**Question 2**).
- It is essential that centres make up solutions and provide apparatus in accordance with the details contained in the Confidential Instructions. If there is difficulty in obtaining some substances, then the centre should contact Cambridge Assessment for advice.
- When plotting graphs, points should be plotted as a cross (×) or an encircled dot (⊙) and not obscured by the graph line, which should be drawn using a sharp pencil. Straight lines of best fit should be drawn with the aid of a ruler and not drawn freehand. 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 (ASE)).
- 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**), where a question states, ‘Test any gas produced’, then candidates are expected to test the gas and record the details for the gas test that gave a positive result. Candidates are expected to use the term ‘precipitate’ when describing the formation of a solid from the reaction between two solutions; if, when two solutions are mixed, the product becomes cloudy and opaque then a precipitate has been formed. To state that a gas is given off is not an observation. The relevant observation would be ‘effervescence’ or ‘fizzing’ or ‘bubbles’ (of a gas).
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit will not be awarded.
- In qualitative analysis, not all the tests described will necessarily give a positive result; a negative test result is useful since it tells us that a certain ion is **not** in the compound being tested.

General comments

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

In **Question 1**, most candidates obtained results that showed the expected trend, although some candidates obtained temperatures or pH values that could not be obtained with the materials and apparatus specified in the Confidential Instructions.

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.

<u>Comments on specific questions</u>

Question 1

(a) Almost all candidates were able to correctly record results that showed the expected trends in temperatures and pH.

(b) While many fully correct graphs were seen, there were several common errors, these were:

- Use of inappropriate graph scales. The expected graph scale was each large grid square being equivalent to 2 °C. Most scales selected did not meet the requirements described in the Key Messages section of this report.
- As well as plotting errors caused by the selection of a difficult scale, it was common for candidates to plot the data for experiments 4, 5 and 6 at volumes of 4.0, 5.0 and 6.0 cm^3 rather than volumes of 6.0, 7.0 and 8.0 cm^3.
- A minority of candidates did not extend their lines so that they crossed.

(c) (i) Most candidates indicated on the graph where they were taking their reading from and correctly recorded the volume of dilute hydrochloric acid. Few candidates then calculated the volume of aqueous sodium hydroxide. Instead, they recorded the temperature at the indicated point on their graph. The expected answer was that the volume of aqueous sodium hydroxide was evaluated to be 10 minus the volume of dilute hydrochloric acid; this is because the total volume in each experiment was 10 cm^3.

(ii) This question proved to be demanding. In the stem to **(c)**, candidates were told that at the point where the lines cross, a neutral solution is formed. Hence, the expected answer was pH 7.

(iii) This required a comparison of the two volumes recorded in **(c)(i)**. An error carried forward from the volumes recorded was allowed. The expected answer was that the hydrochloric acid was the more concentrated because a lower volume of it was required to produce a neutral solution. A very common error was to state that the sodium hydroxide was more concentrated because it had a larger volume.

(d) Most candidates realised that the polystyrene would act as an insulator; many did not realise that because this is an exothermic reaction, it would mean that less heat energy would be lost resulting in a higher temperature.

(e) Better performing candidates could explain why a volumetric pipette could not be used. Some candidates were confused between volumetric pipettes and teat or Pasteur pipettes. A volumetric pipette has a single graduation line and will accurately measure only one specific volume; as this experiment required a variety of different volumes, a volumetric pipette would not be able to measure them all.

Question 2

(a) Most candidates correctly reported the formation of a white precipitate. A few of these candidates noted that the precipitate redissolved in excess aqueous sodium hydroxide.

(b) (i) Candidates who noted that a white precipitate redissolved in excess sodium hydroxide in **(a)**, almost always correctly identified the two possible cations as zinc ions and aluminium ions. If the precipitate was not seen to redissolve in excess, then the expected ions were calcium ions and any other Group II metal ion.

(ii) The correct additional test depended on the ions given in **(b)(i)**. Where aluminium ions and zinc ions were given, the correct test to differentiate between them is the addition of <u>excess</u> aqueous ammonia. If calcium ions had been given in **(b)(i)** then a flame test could be used.

(c) As **K** did not contain sulfite ions, the acidified aqueous potassium manganate(VII) should not have reacted and so the solution should have become a pale pink colour. Candidates who stated the solution became purple gained credit but if the solution became purple, rather than pale pink, it suggests that more than a few drops were added. Some candidates reported that just the top part of the solution became purple; this suggests the contents of the test-tube had not been mixed.

(d) In this test, a white precipitate should have been formed. This was correctly noted by most candidates.

(e) Candidates who noted the formation of a white precipitate in **(d)** almost always stated that **K** contained chloride ions. Candidates who stated that a cream precipitate formed in **(d)** needed to state that **K** contained bromide ions.

(f) Almost all candidates correctly noted the formation of a yellow flame. Orange is an acceptable alternative for the yellow colour produced by sodium ions. Orange-red is not acceptable, as this is the colour produced by calcium ions rather than sodium ions.

(g) As the question instructs candidates to test any gas produced, credit was available for describing and reporting the result of a positive gas test that they carried out. The expected observations were that the solid became a liquid and that the gas given off relit a glowing splint. Many gases, such as hydrogen, ammonia, carbon dioxide and chlorine were identified by candidates even though the only gas that can be made by heating sodium nitrate in a Bunsen flame is oxygen.

(h) The question instructs candidates to test any gas produced and credit was available for describing and reporting the result of a positive gas test that they carried out. In this case, the gas produced should have been ammonia and so the fact that red litmus turned blue should have been noted. Bubbling should also be evident in this test, which was noted by a few candidates.

(i) Better performing candidates correctly identified **L**. Candidates who noted an orange-red colour in the flame test were allowed an error carried forward and the identification of calcium ions was credited. However, it should be noted that an orange flame colour does not indicate calcium ions; the flame colour for calcium ions is orange-red (sometimes referred to as brick red). An orange flame colour is accepted for sodium ions. A common error was to identify one of the ions as ammonium – presumably due to the production of ammonia in **(h)**.

Question 3

Some excellent and succinct descriptions of this quantitative task were seen, with better performing candidates gaining full credit.

By far the most common error was for candidates to think that solubility referred to how quickly something dissolved rather than how much of something would dissolve. Answers based on time taken to dissolve rather than the mass that would dissolve did not gain full credit.

As this was a quantitative task, credit was available for controlling the quantities used; these were the **mass** of sodium sulfate and the **volume** of water. The term ‘amount’ is not credited when a mass or a volume is required.

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

- use of a known/measured/stated volume of water
- use of a known/measured/stated mass of sodium sulfate
- use of an appropriate named container – such as a beaker
- stirring the mixture of water and sodium sulfate to aid dissolution
- repeating the method at different temperatures.

The most common correct methods were to add a known mass of sodium sulfate to a fixed volume of water, remove the sodium sulfate that had not dissolved by filtration and determine the mass of the undissolved sodium sulfate after drying.

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 responses. The aim of the plan is already given in the question and credit will not be awarded 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.

CHEMISTRY

Paper 0620/53
Paper 5 Practical Test

Key messages

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

General comments

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

In answering the planning question (**Question 3**), there is no need for candidates to 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) Candidates performed well on this question. Most candidates were able to record burette readings and calculate the volumes added. The most common errors were not giving all burette readings to a consistent number of decimal places and swapping the initial and final burette readings over or recording the initial burette reading as '50.0' (presumably rather than '0.0'). A few candidates added the two burette readings to calculate the titre rather than subtracting them.

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

(ii) The colour change for thymolphthalein was known by very few candidates.

(c) Almost all candidates were able to identify carbon dioxide as the gas that was given off.

(d) (i) Most candidates realised that washing the burette was not needed as the same solution was used.

(ii) Candidates knew that rinsing was needed to remove the remaining chemicals from the previous experiment to avoid contamination.

(iii) This question proved to be the most difficult on the paper, with very few candidates realising that drying the conical flask to remove the remains of the distilled water would have no effect on the titration volumes. Answers stating that the volume of aqueous sodium hydroxide would increase, or decrease were very common. An increase was often incorrectly explained by the fact the volume of the acid would have been increased by the water and the decrease incorrectly explained by the fact the water would have diluted the hydrochloric acid.

(e) (i) Nearly all candidates could work out that the volume used was higher in Experiment 1 than in Experiment 2, with more than half calculating correctly that it was three times as much.

(ii) Most candidates realised that the difference in titres was caused by the addition of the calcium carbonate; fewer stated that it had neutralised some of the acid. A common error was to state the calcium carbonate was a catalyst for the reaction.

(iii) This was a difficult calculation. Common errors were to double or halve the titre for Experiment 2. The correct method was to calculate the difference between the titres in Experiment 2, this figure being the reduction in the titre caused by the addition of 0.50 g of calcium carbonate. If this number is then divided by 2, the expected reduction in titre for the addition of 0.25 g of calcium carbonate is obtained. Subtracting this figure from the titre for Experiment 1 gives the new expected titre. Numerically, it is the same as finding the mean of the titres in Experiment 1 and Experiment 2. Many candidates omitted the unit for volume, cm^3.

(f) Most candidates correctly repeated the experiments to check reliability but only about half went on to compare the results.

Question 2

(a) Many candidates got an incorrect flame colour for potassium, possibly caused by traces of sodium in the potassium compound. This is one of the reasons that Cambridge asks for the supervisor to carry out the practical tests themselves. If a supervisor reports an unexpected flame colour, then this is taken into consideration when candidates' scripts are marked. The correct colour, in this case lilac, will always be awarded credit.

Cambridge does not limit centres to one method for carrying out flame tests, the choice is up to the centre. However, new or clean nichrome wires give reliable results. Splints which have been immersed in distilled water or dilute hydrochloric acid for at least 24 hours also give good results. If the salt being used is not a halide, then dilute hydrochloric acid should be used to give a good flame colour.

(b) Most candidates correctly observed a blue solution; fewer candidates noticed effervescence during the reaction.

(c) Most candidates observed a green precipitate that dissolved in excess to form a green solution. A few candidates appeared not to be familiar with the term 'precipitate'.

(d) Most candidates correctly observed that there was no change in this reaction. In analysis, negative results can be as important as positive ones.

(e) Most candidates correctly observed that a white precipitate was formed.

(f) Most candidates correctly identified at least two of the three ions. Where appropriate, an error carried forward from the flame test colour reported in **(a)** was allowed. It should be noted that while 'orange' alone is accepted for the yellow colour produced by sodium ions, it is **not** accepted for the red-orange colour produced by calcium ions.

(g) Most candidates gave a pH in the correct range of 1 to 3.

(h) Most candidates realised that the gas was hydrogen. 'Effervescence' or 'fizzing' was often not stated. Many simply named the test for hydrogen rather than describing it.

(i) Most candidates correctly observed that a white precipitate was formed.

(j) Many candidates realised that the solution was hydrochloric acid.

Question 3

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

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

Most candidates used a method based on timing the production of the volume of oxygen. This could be either the time to collect a fixed volume or the volume collected in a fixed time.

The expected steps in the plan were:

- a stated or fixed volume of hydrogen peroxide
- a stated or fixed mass of manganese(IV) oxide
- reacted together in a named suitable container
- suitable apparatus for measurement (usually a gas syringe)
- the actual measurement (for example time to collect a fixed volume of gas)
- repeats with the hydrogen peroxide at different temperatures
- a conclusion linking the measurements to the rate of reaction.

Many excellent and succinct answers were seen. However, a common reason for candidates not obtaining full credit was the omission of details. Some candidates did not specify a suitable container in which to carry out the reaction or used an unsuitable container, such as a measuring cylinder or a beaker to which they attached a gas syringe.

By far the most common error was changing the temperature after the manganese(IV) oxide had been added to the hydrogen peroxide. Others based their conclusion about the rate of the reaction by linking it to the temperature rather than to the measured volume or time. A few candidates believed that the mass of manganese(IV) oxide did not need to be constant as it was the catalyst.

Candidates would be well advised to plan the investigation before starting to write their answer. It was common for candidates to get to the end of their plan and then realise that they needed to find the mass of the manganese(IV) oxide before they started. Many added this as a last line to their plan; 'At the start of the experiment the mass of the manganese(IV) oxide should be found'.

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 responses. The aim of the plan is already given in the question and credit will not be awarded 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.

CHEMISTRY

Paper 0620/61
Paper 6 Alternative to Practical

Key messages

- When plotting graphs, points should be plotted as a cross (×) 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 and should not wobble from point to point. Candidates will need to decide if the points lie on a straight line or a curve. 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 (ASE)).
- 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 for 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 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

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

In answering the planning question (**Question 4**), there is no need for candidates to write a list of apparatus at the start, 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) Many candidates knew that the spots of dye should go on the baseline and that the solvent must reach over the bottom of the paper but not reach up to the spots of dye on the baseline. Some candidates incorrectly filled the beaker with ethanol to well above the baseline or placed the spots above, or below, the baseline.

(b) When to remove the chromatography paper from the ethanol was not well known. The most common errors were to state that it should be removed either when the solvent reaches the top of the paper or when the spots stop moving. The paper should be removed from the solvent shortly before the solvent reaches the top of the paper.

(c) Most candidates were able to draw at least one correct conclusion from the results. The expected conclusions were that dyes 1 and 3 were each made of a single substance (they were pure) and that dye 2 was a mixture of dye 1 and dye 3. Answers which just described the chromatogram did not gain credit. It was a common misconception that lighter colours would rise higher than darker colours and so conclusions such as dye 3 is lighter than dye 1 were seen.

Question 2

(a) Almost all candidates gained some credit by completing the table. Common errors included:

- Thermometer diagrams were not read and recorded to the nearest half scale division. For example, giving 26.5 as either 26 or 27 or 59.5 as either 59 or 60.
- Temperatures were not given to 1 decimal place. For example, 31.0 was expected rather than 31 since readings recorded from a given item of apparatus should all be recorded to the same resolution (the same number of decimal places).
- Times were recorded in minutes and seconds rather than just in seconds as indicated by the units in the column header.

(b) Many fully correct graphs were seen. Common errors included:

- Use of inappropriate graph scales. The expected graph scale was each large grid square being equivalent to 50 seconds. It was common for graph scales to use each large grid square as 60 seconds. Candidates who did this struggled to plot the data correctly. Scales that had each large grid square as 1 minute were very problematical when candidates tried to plot the data. For example, 1 minute and 50 seconds were plotted as 1.50 rather than 1.83.
- A significant number of candidates drew a straight line through their points. It should be noted that if the points at either end of a straight line are on one side of the line and the remaining points are on the other side of the line then the line of best fit should be a curve.

(c) (i) The evaluation of 100 divided by 44 was often completed correctly. Some candidates rounded their answer incorrectly. Many candidates correctly deduced the units for the average rate.

(ii) This was normally answered correctly. The most common incorrect answer being 'experiment 1'.

(d) The extrapolation of the line was often done correctly. A significant number of candidates needed to show how they obtained their answer from the graph for further credit. When reading from a graph, it is a good idea to draw construction lines from the line to the axes.

(e) Most candidates correctly indicated that the 50 cm^3 measuring cylinder would be the most appropriate.

(f) (i) This proved to be demanding, with relatively few fully correct answers.

Better performing candidates were able to state that air was collected because at the start, the conical flask and delivery tube contained air. Weaker responses simply stated, 'air is everywhere'.

(ii) The most common incorrect answer was to state that 'the air does not react' or that 'air contains carbon dioxide', both of which are true statements but neither of which explains why the air does not affect the accuracy of the results. Only a small number of candidates could state that the volume of air collected was the same as the volume of carbon dioxide that displaced it.

(g) In this investigation the independent variable was the temperature of the acid. In the question, candidates were told that the temperature of the acid decreased during each experiment. The better performing candidates were able to state that heat energy was being lost to the surroundings and that this could be reduced by using insulation. Candidates who gave answers based on the reaction being endothermic gained credit for stating a water bath would help maintain the temperature. A few candidates tried to explain that the temperature decrease was due to the reaction being exothermic rather than endothermic.

Question 3

(a) (i) Hydrated solids will give off water when heated. The test for the presence of water using anhydrous cobalt chloride was not well known. Many candidates gave observations more appropriate for litmus paper than anhydrous cobalt chloride.

(ii) Most candidates correctly identified the gas as oxygen.

(b) (i) The provision of the 'Notes for use in qualitative analysis' meant that most candidates were able to state correctly that a green precipitate would form and that the green precipitate would dissolve in excess.

(ii) The question stated, 'The student tests for any gas produced'; candidates should have included the test and result in their answer. As **M** was chromium(III) nitrate, the gas produced was ammonia, and so a reference to damp red litmus paper turning blue was expected.

(c) Many descriptions of how to carry out a flame test were insufficient. The best answers included:

- A description of how to get the sample into a flame. This could have been on a wire (preferably nichrome or platinum) or a dampened wooden splint.
- A description of where the sample was placed and the type of flame used – which should have been **IN** a roaring (or blue) Bunsen flame. The sample is not placed above or near the flame.

Several candidates heated the sample on a spatula or in a test-tube.

(d) Many candidates were able to correctly identify **N** as barium iodide. Weaker candidates identified the anion as being the sulfate ion. **Test 4** was the test for sulfate ions, but the result was negative therefore these ions were not present.

Question 4

Some excellent and succinct descriptions of this quantitative task were seen, with better performing candidates gaining full credit.

As this was a quantitative task, credit was available for controlling the quantities used which was the **volume** of cleaner. The term 'amount' is not credited when a volume is required.

There were several possible approaches that could have been used. The most common correct method was to carry out a titration. Common errors included:

- Not naming the apparatus used to measure out the required volume of the cleaner.
- Not naming an appropriate indicator and the colour change that would be seen at the end point.

A common method that would not work was the use of litmus paper to test the cleaners – red litmus paper will turn blue regardless of the concentration of the ammonia in the cleaner and the time it takes to turn blue is not related to the concentration of the ammonia in the solution; the colour change will be instantaneous.

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 responses. The aim of the plan is already given in the question and credit will not be awarded 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.

CHEMISTRY

Paper 0620/62
Paper 6 Alternative to Practical

Key messages

- When plotting graphs, points should be plotted as a cross (×) 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 and should not wobble from point to point. Candidates will need to decide if the points lie on a straight line or a curve. 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 (ASE)).

- 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 for 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 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

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

In answering the planning question (**Question 4**), there is no need for candidates to write a list of apparatus at the start, 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) Most candidates were able to name the apparatus required as a pestle and mortar.

(b) Most candidates were able to correctly state that excess dilute hydrochloric acid was necessary to ensure that all the calcium carbonate in the seashells reacts. A few candidates incorrectly stated that all the acid would react or gave answers based on reaction rate.

(c) Most candidates correctly identified the funnel and the conical flask. The most common errors were to identify **A** as a filter and **B** as a beaker. 'Filter funnel' is acceptable but 'filter' on its own is not. It should be noted that **A** is not a separating funnel, although it is used to separate a solid from a liquid. The term separating funnel is the name used for apparatus with a tap that is used to separate immiscible liquids of differing densities.

(d) (i) Most candidates correctly stated that the impurity is calcium chloride (the salt made during the reaction) or hydrochloric acid (which was added in excess). A significant number of other candidates identified the impurity as a gas (commonly carbon dioxide) or silicon(IV) oxide – which is the substance that is being isolated by filtration and makes up most of the residue.

(ii) Almost all candidates realised that the mass of the residue had to be found. Few candidates realised that the residue needed to be dried before the mass was found.

Question 2

(a) Almost all candidates gained credit for recording the volumes of aqueous sodium hydroxide. A small number of candidates did not record the thermometer readings to half a scale division – and so incorrectly recorded the reading for experiment 4 as 30 °C or 31 °C rather than 30.5 °C, or for experiment 6 as 27 °C or 28 °C rather than 27.5 °C. Credit was awarded for having all thermometer readings and volumes recorded to 1 decimal place. Most candidates did this for the masses; they often did not do this for the temperatures, for example recording 26 °C rather than 26.0 °C.

(b) Many fully correct graphs were seen. Common errors included:

- Use of inappropriate graph scales. The expected graph scale was each large grid square being equivalent to 2 °C. In this case candidates were told that the scale on the *y*-axis should extend by at least 2 °C above the highest temperature in Table 2.1, meaning the scale should have extended to at least 32.5 °C. The expectation was that the scale, from 26.0 °C to 32.5 °C, would take up over half of the available space on the *y*-axis. Most scales selected did not meet this requirement. It was very common for scales to be chosen where each large grid square was equivalent to 6.5 or 7.0 °C. Candidates who chose awkward scales very often plotted points incorrectly.
- As well as plotting errors caused by the selection of a difficult scale, it was common for candidates to plot the data for experiments 4, 5 and 6 at volumes of 4.0, 5.0 and 6.0 cm^3 rather than volumes of 6.0, 7.0 and 8.0 cm^3.
- A minority of candidates did not extend their lines so that they crossed.

(c) (i) Most candidates indicated on the graph where they were taking their reading from and correctly recorded the volume of dilute hydrochloric acid. Few candidates then calculated the volume of aqueous sodium hydroxide. Instead, they recorded the temperature at the indicated point on their graph. The expected answer was that the volume of aqueous sodium hydroxide was evaluated to be 10 minus the volume of dilute hydrochloric acid; this is because the total volume in each experiment was 10 cm^3.

(ii) This question proved to be demanding. In the stem to **(c)**, candidates were told that at the point where the lines cross, a neutral solution is formed. Hence, the expected answer was pH 7.

(iii) This required a comparison of the two volumes recorded in **(c)(i)**. An error carried forward from the volumes recorded was allowed. The expected answer was that the hydrochloric acid was the more concentrated because a lower volume of it was required to produce a neutral solution. A very common error was to state that the sodium hydroxide was more concentrated because it had a larger volume.

(d) Most candidates realised that the polystyrene would act as an insulator; many did not realise that because this is an exothermic reaction, it would mean that less heat energy would be lost resulting in a higher temperature.

(e) Better performing candidates could explain why a volumetric pipette could not be used. Some candidates were confused between volumetric pipettes and teat or Pasteur pipettes. A volumetric pipette has a single graduation line and will accurately measure only one specific volume; as this experiment required a variety of different volumes, a volumetric pipette would not be able to measure them all.

Question 3

(a) (i) Most candidates correctly stated that **K** could contain zinc ions or aluminium ions.

(ii) Most candidates correctly suggested adding excess aqueous ammonia, which would cause any precipitate caused by zinc ions to redissolve. Common errors were to state that drops of ammonia could be added, which must be incorrect as that is the test that has just been done, or to use aqueous sodium hydroxide, which would give the same result for both zinc and aluminium ions.

(b) Most candidates correctly stated that the anion was the bromide ion.

(c) With the 'Notes for use in qualitative analysis' now included on the examination paper, almost all candidates were able to state that a green flame would be seen.

(d) In this question, candidates were told that the student tested for any gas produced. Answers should have included the test and result for the gas that was produced – in this case the gas was ammonia and so candidates should have noted that damp red litmus paper turned blue. The most common error was to just state that the gas made was ammonia; this is not an observation and so did not gain credit.

(e) The test was the test for a halide ion. As **L** is barium nitrate, it does not contain a halide ion and so there would have been no reaction. Candidates found negative tests more difficult than positive tests, but they should be familiar with them as they provide useful information by showing what something is not.

(f) This proved to be the most demanding part of **Question 3**. The better performing candidates realised that aqueous barium nitrate is used in the test for sulfate ions and so a white precipitate will be formed.

Question 4

Some excellent and succinct descriptions of this quantitative task were seen, with better performing candidates gaining full credit.

By far the most common error was for candidates to think that solubility referred to how quickly something dissolved rather than how much of something would dissolve. Answers based on time taken to dissolve rather than the mass that would dissolve did not gain full credit.

As this was a quantitative task, credit was available for controlling the quantities used; these were the **mass** of sodium sulfate and the **volume** of water. The term 'amount' is not credited when a mass or a volume is required.

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

- use of a known/measured/stated volume of water
- use of a known/measured/stated mass of sodium sulfate
- use of an appropriate named container – such as a beaker
- stirring the mixture of water and sodium sulfate to aid dissolution
- repeating the method at different temperatures.

The most common correct methods were to add a known mass of sodium sulfate to a fixed volume of water, remove the sodium sulfate that had not dissolved by filtration and determine the mass of the undissolved sodium sulfate after drying.

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 responses. The aim of the plan is already given in the question and credit will not be awarded 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.

CHEMISTRY

Paper 0620/63
Paper 6 Alternative to Practical

Key messages

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

General comments

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

In answering the planning question (**Question 4**), there is no need for candidates to spend time writing a list of variables or to write a list of apparatus at the start, nor the aims of the experiment. Where there is credit available for the use of suitable apparatus, then 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.

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

Comments on specific questions

Question 1

(a) Most candidates correctly identified the apparatus as a crucible, although an evaporating basin or dish was also acceptable.

(b) This question was very well answered. Nearly everyone identified from the stem that hydrogen chloride was toxic.

(c) Most candidates realised that, to get a very hot Bunsen flame, the air holes had to be fully open. Weaker responses simply stated, 'turn the gas up'.

(d) (i) Most candidates realised that the mass loss was caused by the escape of the gases, steam and hydrogen chloride.

(ii) This question discriminated well with the better performing candidates realising that heating to constant mass was the answer.

(e) (i) Many candidates correctly answered that steam has been cooled down by the ice bath and condensed to water.

(ii) Boiling and melting points as a test for impurity were well known. In this example other methods such as, the test for chloride ions or a pH test were also acceptable. A few candidates misread the question and gave the test for pure water.

Question 2

(a) Most candidates successfully completed the table with all four volumes read correctly and correct calculations of the volumes added. Most answers were given to 1 decimal place. Only a very small proportion recorded volumes incorrectly, for example 8 cm^3 instead of 8.0 cm^3.

(b) About half the colour changes of methyl orange during this titration were given correctly, with most of the others simply getting the colours reversed.

(c) Almost all candidates were able to identify carbon dioxide as the gas that was given off.

(d) (i) Most candidates realised that washing the burette was not needed as the same solution was used.

(ii) Candidates knew that rinsing was needed to remove the remaining chemicals from the previous experiment to avoid contamination.

(iii) This question proved to be the most difficult on the paper, with very few realising that drying the conical flask to remove the remains of the distilled water would have no effect on the titration volumes, as the quantity of acid involved was unchanged. Answers stating that the volume of aqueous sodium hydroxide would increase, or decrease were very common. An increase was often incorrectly explained by the fact the volume of the acid would have been increased by the water and the decrease incorrectly explained by the fact the water would have diluted the hydrochloric acid.

(e) (i) Nearly all candidates could work out that the volume used was higher in Experiment 1 than in Experiment 2, with more than half calculating correctly that it was three times as much. A few just quoted the volumes added from the table and this did not gain credit.

(ii) Most candidates realised that the difference in titres was caused by the addition of the calcium carbonate; fewer stated that it had neutralised some of the acid. A common error was to state the calcium carbonate was a catalyst for the reaction.

(iii) This was a difficult calculation. Common errors were to double or halve the titre for Experiment 2. The correct method was to calculate the difference between the titres in Experiment 2, this figure being the reduction in the titre caused by the addition of 0.50 g of calcium carbonate. If this number is then divided by 2, the expected reduction in titre for the addition of 0.25 g of calcium carbonate is obtained. Subtracting this figure from the titre for Experiment 1 gives the new expected titre. Numerically, it is the same as finding the mean of the titres in Experiment 1 and Experiment 2. Many candidates omitted the unit for volume, cm^3.

(f) Most candidates correctly repeated the experiments to improve reliability but only about half went on to compare the results.

Question 3

(a) It was evident that most candidates could use the notes for use in qualitative analysis attached to the question paper as nearly all candidates gained full credit.

(b) Most candidates correctly stated there would be no change seen.

(c) Most knew that there would be a white precipitate formed.

(d) Most candidates could work out the pH from the colour change of universal indicator paper.

(e) Nearly all correctly identified hydrogen as the gas.

(f) Most candidates correctly named at least two of the three ions, with some getting all three correct.

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

Most candidates used a method based on timing the production of the volume of oxygen. This could be either the time to collect a fixed volume or the volume collected in a fixed time.

The expected steps in the plan were:

- a stated or fixed volume of hydrogen peroxide
- a stated or fixed mass of manganese(IV) oxide
- reacted together in a named suitable container
- suitable apparatus for measurement (usually a gas syringe)
- the actual measurement (for example time to collect a fixed volume of gas)
- repeats with the hydrogen peroxide at different temperatures
- a conclusion linking the measurements to the rate of reaction.

Many excellent and succinct answers were seen. However, a common reason for candidates not obtaining full credit was the omission of details. Some candidates did not specify a suitable container in which to carry out the reaction or used an unsuitable container, such as a measuring cylinder or a beaker to which they attached a gas syringe.

By far the most common error was changing the temperature after the manganese(IV) oxide had been added to the hydrogen peroxide. Others based their conclusion about the rate of the reaction by linking it to the temperature rather than to the measured volume or time. A few candidates believed that the mass of manganese(IV) oxide did not need to be constant as it was the catalyst.

Candidates would be well advised to plan the investigation before starting to write their answer. It was common for candidates to get to the end of their plan and then realise that they needed to find the mass of the manganese(IV) oxide before they started. Many added this as a last line to their plan; ‘At the start of the experiment the mass of the manganese(IV) oxide should be found’.

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