

CHEMISTRY

Paper 0620/11
Multiple Choice (Core)

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

General comments

Questions 11 and 26 proved to be of lower demand.

Questions 17, 25, 27 and 32 proved to be more challenging.

Comments on specific questions

The following responses were popular wrong answers to the questions listed.

Question 2

Response **D** was slightly more popular than the correct one. Candidates did not appreciate that a burette is necessary to measure 0.1 cm^3 accurately.

Questions 3

This had an approximately equal number of candidates choosing each alternative. This indicates that a high proportion of candidates were guessing the answer.

Question 8

Response **B**. This was slightly more popular than the correct one. Candidates simply divided 120 by 12 rather than correctly using the information given.

Question 10

Response **C**. Nitrogen was a popular incorrect choice.

Question 13

Response **A**. More candidates chose this response than chose the correct one. They recognised the correct colour change and read no further.

Questions 17

This had an approximately equal number of candidates choosing each alternative.

Question 19

Response **A**. Candidates did not read the question properly and opted for an element in the same group.

Question 25

Response **C**. The chemistry of the blast furnace was poorly understood. Few candidates selected the correct response.

Question 27

Response **C**. This was more popular than the correct response. Candidates found the mathematics challenging and may have been unfamiliar with the experiment.

Question 29

Response **D**. This response was much more popular than the correct one. Candidates did not know that tap water contains dissolved substances and missed the term *soluble* in option 2.

Question 32

Response **A**. This was more popular than the correct response. Candidates were not familiar with sulfur dioxide and its uses.

Questions 38

This had an approximately equal number of candidates choosing each alternative.

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Paper 0620/12
Multiple Choice (Core)

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

General comments

Questions 9, 15, 17, 22, 25 and 29 proved to be the most challenging.

Comments on specific questions

The following responses were popular wrong answers to the questions listed.

Question 1

Response A. Candidates did not know the meaning of the term *sublimation*.

Question 4

Response **B**. This response was more popular than the correct response. Candidates did not appreciate that hydrogen has no neutrons.

Question 8

Response **B**. Candidates did not understand the mathematical process involved and simply divided 120 by 12.

Question 9

Response **C**. This response was more popular than the correct response. Candidates knew that lead moves to the negative electrode but selected the wrong option.

Question 11

Response **D**. It was a common misconception that because the reaction loses energy candidates assumed that temperature goes down whereas the energy released by the reaction causes it to increase.

Question 13

Response **C**. Candidates may not have read the second column of the table.

Question 15

Responses **A** and **D** were both more popular than the correct answer. Candidates did not know the tests for the different gases listed in the syllabus.

Question 18

This had an approximately equal number of candidates choosing each alternative. This indicates that a high proportion of candidates were guessing the answer.

Question 22

Response **B** was more popular than the correct one. Candidates often forget that helium, a noble gas, has only two electrons.

Question 24

This had an approximately equal number of candidates choosing each alternative.

Question 25

Response **C** was more popular than the correct response. Candidates did not know all the chemical reactions that take place in the blast furnace.

Question 26

This had an approximately equal number of candidates choosing each alternative.

Question 30

This had an approximately equal number of candidates choosing each alternative.

Question 34

Response **C**. Candidates realised that the result was 'neutral' but were unsure of the initial nature of the waste.

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Paper 0620/13
Multiple Choice (Core)

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

General comments

Questions 2, 15, 32 and 37 proved to be of lower demand.

Questions 10, 16, 18, 22, 23, 24, 30 and 31 proved to be particularly challenging.

Comments on specific questions

The following responses were popular wrong answers to the questions listed.

Question 6

Response **B**. Candidates realised that Q was a metal but did not know the bonding in hydrogen.

Question 7

Response **B**. Candidates elected an option which, whilst true, does not answer the question.

Question 8

Response **B**. Candidates did not understand the mathematical process involved and simply divided 120 by 12.

Question 9

Response **A**. Candidates missed the term *molten* in the stem of the question.

Question 10

Response **A**. This response was more popular than the correct response. Hydrogen, a fuel, does not release carbon dioxide whereas all fuels release heat.

Question 11

Response **D**. This response was more popular than the correct response. Candidates were confused by the two prefixes 'exo' and 'endo'.

Question 16

This had an approximately equal number of candidates choosing each alternative. This indicates that a high proportion of candidates were guessing the answer.

Question 18

Response **D**. This was more popular than the correct response. Candidates rejected the three previous options, not realising that a carbonate would have fizzed producing carbon dioxide.

Question 22

Response **A**. This response was more popular than the correct one. Candidates did not consult their Periodic Table and assumed all noble gases have eight electrons in their outer shell.

Question 23

Response **A**. This was more popular than the correct response. Candidates did not know that an alloy shows a random distribution of the atoms of the second metal.

Question 24

Response **D**. This response was more popular than the correct response. The least reactive metals have oxides which react with carbon.

Question 31

Response **B**. This response was more popular than the correct response. Candidates knew that greenhouse gases absorb heat but did not think their answer through.

Question 39

Response **B**. Candidates knew about fermentation but did not remember the ethene process as an addition reaction.

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Paper 0620/21
Multiple Choice (Extended)

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

General comments

Questions 4, 5, 6, 25, 29, 32, 34 and 40 proved to be of lower demand.

Comments on specific questions

The following responses were popular wrong answers to the questions listed.

Question 8

Response **C**. Candidates realised from the equation that there was a difference with a factor of two. However, they applied it in the wrong direction.

Question 16

Response **C**. Candidates confused oxidising agent with the substance being oxidised.

Question 23

Response **B**. Candidates did not realise that both the elements and the compounds show catalytic activity.

Question 24

Response **D**. Candidates did not realise that copper does not react with dilute acids and missed the electrical conduction.

Question 30

Response **D**. Candidates did not realise that tap water is not pure as it contains dissolved solids, and missed the term *soluble* in option 2.

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Paper 0620/22
Multiple Choice (Extended)

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

General comments

Questions 4, 7, 9, 17, 21, 25, 29 and 32 proved to be of lower demand.

Question 2 proved to be particularly challenging.

Comments on specific questions

The following responses were popular wrong answers to the questions listed.

Question 1

Response **A**. Candidates chose the lightest gas but omitted to take into account the indicator colour change.

Question 2

Response **D**. This response was more popular than the correct response. Candidates did not realise that two substances with the same R_f value would not separate at all.

Question 30

Response **D**. Candidates did not realise that tap water contains dissolved solids. They also missed the term *soluble* in option 2.

Question 35

Response **B**. Candidates were not familiar with the names for the fractions given in the syllabus.

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Paper 0620/23
Multiple Choice (Extended)

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

General comments

Questions 2, 3, 4, 7, 21, 22, 27, 29, 32 and 33 proved to be of lower demand.

Questions 9, 20 and 30 proved to be particularly challenging.

Comments on specific questions

The following responses were popular wrong answers to the questions listed.

Question 1

Response **B**. Candidates knew that the answer involved diffusion but did not understand the reason for this.

Question 5

Response **D** is true but does not answer the question. It is electrons which determine chemical properties.

Question 6

Response **D**. Candidates did not fully understand the structure of solid silicon dioxide, only knowing that it was similar to diamond.

Question 9

Response **B**. This response was more popular than the correct response. Candidates got part of the way with the calculation but added less water instead of more.

Question 10

Response **A**. Candidates did not take into account the copper electrodes.

Question 15

Response **C**. Candidates may have been thinking of rate of production rather than yield.

Question 18

This had an approximately equal number of candidates choosing each alternative. This indicates that a high proportion of candidates were guessing the answer.

Question 24

Response **A**. Candidates should realise that the second metal atoms are randomly distributed through the metallic structure.

Question 28

Response **C**. Candidates knew it must be higher but selected wrongly, possibly without doing the maths.

Question 30

Responses **A** and **D** were both more popular than the correct response. Candidates missed the term *soluble* in option 2 and then found the question challenging.

Question 34

Response **D**. Candidates confused lime with slaked lime.

Question 35

Response **B**. Candidates did not know the names of the fractions that are given in the syllabus.

CHEMISTRY

Paper 0620/31
Theory (Core)

Key messages

Many candidates needed more practice in questions involving qualitative analysis.

It is important that candidates read questions carefully in order to understand what is exactly being asked.

Many candidates needed more practice in memorising the meaning of chemical terms such as *compound* or *hydrocarbon*.

The balancing of simple equations and extraction of data from tables was generally well done.

General comments

Many candidates tackled this paper well, showing a good knowledge of core Chemistry. Nearly all candidates were entered at the appropriate level. The standard of English was generally good. Most candidates attempted all parts of each question. The exceptions were **Questions 4(e)(i), 5(b), 5(e), 7(a)(i), 8(c) and 8(d)** where a significant number of candidates did not respond.

Many candidates needed more practice in questions involving qualitative analysis. For example, very few candidates knew the test for an unsaturated hydrocarbon (**Question 3(c)(ii)**) or iron(II) ions (**Question 4(e)(i)**).

Some candidates needed more practice in reading and interpreting questions. The rubric was misinterpreted or ignored by some candidates. In **Question 2(b)(ii)** the words 'on health' were ignored. In **Question 4(d)**, many candidates did not refer to the equation as instructed in the stem of the question whilst in **Question 5(a)** some candidates did not choose words from the list. In **Question 6(a)** a considerable number of candidates did not write about the position of the sub-atomic particles in the atom. In **Question 6(c)** some candidates ignored the words 'medical use'.

Many candidates needed more practice in answering questions involving chemical terms without contradicting themselves. For example, in **Question 1(c)**, many candidates wrote about mixtures and in **Question 2(b)(i)** some candidates suggested that hydrocarbons were elements.

Some candidates needed more practice in answering extended questions such as **Questions 3(c)** (diffusion) and **6(a)** (position and number of sub-atomic particles).

Questions involving general chemistry, including organic chemistry, were generally tackled well by many candidates. Many candidates were able to balance simple equations and extract relevant information from tables of data. Others needed more practice in naming salts and understanding the reactions of halogens with halide ions.

Comments on specific questions

Question 1

Parts (a) and (d) were generally well answered. Many candidates identified at least three of the gases correctly in part (a) and gained at least one mark for the electron arrangement in part (d). Fewer gave a suitable explanation for the use of helium in party balloons (part (b)(i)). A greater number gave a correct use of argon in part (b)(ii). The definition of the term *compound* (part (c)) was not well known.

- (a) (i) Many candidates realised that ammonia turns red litmus blue. The commonest error was to suggest sulfur dioxide.
- (ii) A majority of the candidates suggested that sulfur dioxide contributes to acid rain. A wide range of incorrect answers was seen, hydrogen or methane being the commonest.
- (iii) A considerable number of candidates appeared not to take account of the term *hydrocarbon* in the stem of the question and gave the incorrect answer 'carbon dioxide'. Another common error was to suggest 'argon'.
- (iv) A minority of the candidates identified carbon dioxide correctly. The commonest errors were to suggest either 'hydrogen' or 'ammonia'.
- (v) Many candidates identified argon as the noble gas with electronic structure 2.8.8. A wide variety of incorrect answers was seen, the commonest being carbon dioxide, hydrogen or helium.
- (b) (i) A minority of the candidates gave correct answers involving the reactivity or flammability of hydrogen or the inert nature of argon. Others did not gain the mark because they implied that helium is reactive, e.g. 'helium is only slightly reactive'. Many gave answers relating to density; the majority of these suggesting that helium is less dense than hydrogen.
- (ii) Many candidates suggested lights, lamps or similar correct answers. Others thought that argon was an oil, perhaps by mixing up with argan oil, or a fuel. A minority of candidates either referred to the filament in the lamp rather than the surrounding gas or gave vague statements about argon in the atmosphere.
- (c) Few candidates were able to define the term *compound* with the exactitude required. Many described mixtures or unqualified combinations of atoms or sometimes just substances. Many candidates confused atoms, molecules and substances. A large number of candidates, despite referring to bonds or 'joining of different atoms', disadvantaged themselves by starting their explanation with 'a mixture of'.
- (d) Many candidates scored at least one mark, most commonly for the three bonding pairs of electrons. Common errors included: extra non-bonding electrons on one or more hydrogen atoms; extra electrons on the nitrogen atom; three bonding electrons or a single non-bonding electron on the nitrogen. A small number of candidates drew a large number of electrons on a single atom, e.g. up to 12, either on each atom.

Question 2

This question was well answered in parts. In part (a) many candidates answered parts (i) to (iv) correctly. Few candidates worked out that the nitrogen came from the air in part (a)(v). Part (b) was less well done with a minority of the candidates being able to give a satisfactory definition of a hydrocarbon or a suitable effect of carbon monoxide on health. Many candidates were able to balance the equation in part (b)(iii).

- (a) (i) A majority of the candidates gave the correct answer. The commonest errors were to give either 85.5 (the total of the other gases) or a near miss in the calculation, e.g. 15.4.
- (ii) Most candidates identified hydrogen as the gas present in the lowest concentration. The commonest error was to suggest hydrocarbons.
- (iii) Many candidates gave the correct elements. The commonest errors were to suggest nitrogen and carbon dioxide or carbon dioxide and water.

- (iv) A significant number of candidates who gave CO_2 in part (a)(iii) gave the formula of nitrogen dioxide as NCO_2 . Other common errors were N_2O_3 and N_2O .
- (v) A minority of the candidates realised that the nitrogen came from the air / atmosphere. Many suggested that the nitrogen comes from the exhaust, the engine or from the incomplete combustion of the fuel. Others suggested that it comes from reactions involving hydrogen, carbon dioxide or water. A significant number of candidates gave answers which bore no relationship to the question, e.g. 'from industry' or 'from limestone'.
- (b)(i) A minority of the candidates defined a hydrocarbon correctly. Many described mixtures of elements or combinations with other elements. Others omitted the essential idea that there were no other elements present. A significant number of candidates either suggested that hydrocarbons are elements rather than compounds.
- (ii) A minority of candidates gave an answer that referred to the poisonous nature of carbon monoxide. Many suggested that it causes cancer or lung diseases or gave biological descriptions involving haemoglobin (rather than giving the effect on the body). Others gave answers that were too vague, e.g. 'effects breathing'.
- (iii) Many candidates scored at least one mark for balancing the equation, usually for balancing the carbon in the carbon dioxide. The commonest examples of incorrect balancing for the water molecules were $10(\text{H}_2\text{O})$ and $8(\text{H}_2\text{O})$. A small number of candidates gave the incorrect balance of $2\text{CO}_2 + 2\text{H}_2\text{O}$.

Question 3

Few candidates scored well in parts (a)(i) (diffusion) and (a)(ii) (explaining why limonene is a solid at -80°C). Many candidates could define a catalyst in part (b)(i) and oxidation in part (b)(ii) but fewer were able to describe the colour change when bromine is added to an unsaturated compound in part (c)(ii).

- (a)(i) Many candidates recognised that diffusion was occurring. Fewer explained diffusion in terms of the particles moving randomly from areas of higher concentration to areas of lower concentration. Many just described the smell moving or the limonene moving. A minority of the candidates did not recognise the physical process of diffusion and described chemical reactions with the air. Very few candidates wrote about the particles escaping from the liquid to form a vapour.
- (ii) A minority of the candidates gained both marks. Those who scored one mark either did not give an explanation or gave the state as being liquid. Some responses just referred to the melting or boiling points as changing, which was insufficient. A significant number of candidates misunderstood the negative signs and wrote statements such as 'because -80°C is higher than -74°C '.
- (b)(i) A majority of the candidates could describe the purpose of a catalyst. Many seemed to think that all catalysts are enzymes. Common errors were to suggest that a catalyst changes the rate of reaction and this was not a specific enough answer, or to refer to other properties of catalysts, e.g. 'they are not used up in the reaction'. Some candidates suggested incorrectly that catalysts do not take part in the reaction.
- (ii) Many candidates gave a suitable definition of oxidation. Others gave more than one definition and sometimes contradicted themselves by writing incorrect statements such as 'gain of electrons' or 'when you take the oxygen away'. Some candidates referred to the oxygen alone without reference to any other element or gave vague answers such as 'when you oxidise something'.
- (c)(i) Many candidates identified the double bond. The commonest errors were to either refer to the CH_3 group or to the OH group.
- (ii) Some candidates knew the correct colour change when aqueous bromine reacts with an unsaturated compound. Others either reversed the colours (colourless to orange) or guessed the colour of the product, green, purple or blue being commonly seen. Common incorrect colours for aqueous bromine were red or pink. A few candidates suggested white or clear for the colour of the product, which was not accurate enough.

Question 4

Many candidates gave good answers to part **(a)**, **(c)** and **(e)(ii)**. Fewer were able to describe three ways in which the properties of iron differ from those of potassium in part **(b)** and many did not use the equation provided in part **(d)** to explain how the iron(III) oxide is reduced by hydrogen. The test for iron(II) ions in part **(e)(i)** was not well known and in part **(f)** many candidates did not use all the information in the diagram.

- (a)** Some candidates gave the correct order of reactivity but many reversed the order completely. Others seemed to rely on their existing knowledge of the reactivity series rather than using the information in the table. This was obvious from the large number of candidates who wrote down lists of relative reactivity either next to the question or on one of the blank pages.
- (b)** Many candidates gained one or two marks for correct comparisons of the properties of iron and potassium but few gained all three marks. Many described properties which were common to both metals e.g. conductivity. Some thought that one was a metal and the other was a non-metal or described their relative positions in the Periodic Table. A significant number of candidates did not mention which metal they were writing about. Many candidates did not score because they wrote about electronic structure, valency or physical state or did not compare properties sufficiently well, e.g. iron is malleable, rather than less malleable than potassium.
- (c)** Most candidates balanced the equation successfully. The $3(\text{Fe})$ was the mark most often scored. Common errors were $4(\text{Fe}) + 2(\text{O}_2)$; $2(\text{Fe}) + 2(\text{O}_2)$ and $2(\text{Fe}) + 3(\text{O}_2)$.
- (d)** Many candidates gave a definition of reduction but did not apply the concept of reduction to the equation. Others described the equation without explaining how it was a reduction. Many candidates described the iron as losing oxygen rather than the iron oxide losing oxygen.
- (e) (i)** Very few candidates knew the test for iron(II) ions. A wide variety of incorrect test reagents were seen including indicators (mainly litmus), flame tests, barium nitrate and hydrochloric acid. Many described how iron chloride might be formed. A few suggested that a green precipitate would be formed but used the incorrect test reagent. Of those who gave the correct test reagent, about half suggested a red-brown precipitate.
- (ii)** Some candidates gave the correct molecular formula. The commonest error was to suggest FeCl_3 . Other common errors included FeCl_6 , $2\text{Fe}6\text{Cl}$ or $2\text{Fe} + 6\text{Cl}$. Some candidates disadvantaged themselves by writing two formulae, one correct and one incorrect.
- (f)** Few scored more than one mark for this question. Many candidates only chose one bottle. Some candidates realised that calcium chloride dries the air but then assumed that it removed oxygen as well. Many candidates wrote conflicting statements. Some realised that air and water were necessary for rusting but were unable to identify which of the bottles contained only air, only water or both air and water.

Question 5

Most candidates gave a good answer to part **(a)** and many answered parts **(b)** and **(c)** correctly. Fewer candidates predicted the correct electrode products in part **(d)**. Even fewer identified the brown solution or gave a correct explanation in part **(e)**.

- (a)** Most candidates performed well. The commonest errors were: electroplating or heat, instead of break down; element, instead of compound; gaseous or electroplating, instead of molten and electroplating, instead of electricity. A few candidates did not select words from the list.
- (b)** Most candidates gained at least one mark. Some confused the anode with the cathode; others labelled the electrolyte incorrectly. The commonest errors being to label the electrodes or the cell.
- (c)** Many candidates gave a suitable reason for using a graphite electrode. Others just stated that it was a non-metal or gave irrelevant properties such as density, hardness or catalysis. A considerable minority referred to cheapness.
- (d)** Some candidates realised that zinc is formed at the negative electrode. Fewer identified iodine being formed at the positive electrode. Many reversed the products, having the zinc at the positive

electrode. Common errors, applying indiscriminately to each electrode, included hydrogen, oxygen or zinc iodide. A significant number of candidates gave irrelevant answers such as 'electrons' and 'neutrons'.

- (e) A minority of candidates gained one mark and very few gained both marks. The commonest error was to suggest that the brown colour was caused by the formation of bromine even though there was no bromine or bromide in the equation. A considerable number of candidates suggested that zinc chloride is the brown-coloured product. A few candidates recognised that chlorine is more reactive than iodine, but most made the comparison with bromine, zinc bromide or zinc. Others tried to give reasons unrelated to the reactivity series.

Question 6

Candidates responded well to some parts of this question, especially parts (b) and (d). The question about the structure of the atom (part (a)) was less well answered with many candidates ignoring the position of the sub-atomic particles. In part (c), some candidates knew about the medical uses of radioactive isotopes; others did not take note of the word 'medical' in the stem of the question and wrote about other uses.

- (a) The location of electrons was not made clear by many candidates. Statements such as 'in energy levels' or 'in shells' were not sufficient to gain the mark. Many candidates suggested that 'the electrons are outside the atom', rather than outside or surrounding the nucleus. Many gained only three marks because they identified the correct number of number of electrons, protons and neutrons but did not describe their position. Others described the position by trying to relate it to the isotopic symbol, e.g. 'the proton number is lower' or 'the neutrons plus protons are up'.
- (b) Many candidates performed well. Element was nearly always seen.

Some candidates wrote 'molecular' or 'nucleon' in place of 'atomic' or 'ions' in place of 'atoms'. Others did not use words from the list as instructed.
- (c) Some candidates ignored the word 'medical' in the stem of the question and described energy production or testing for leakages in pipelines. Others wrote vague statements such as 'in medicines' or incorrect statements such as 'chemotherapy'.
- (d) A majority of the candidates recognised the isotope of uranium. The commonest error was to suggest the isotope of iodine. The isotope of xenon was also selected by a minority of candidates.

Question 7

Parts (a)(i), (a)(iii), (b) and (d) of this question were answered well by a majority of the candidates. In part (a)(ii) the direction of the trend was not always made clear whilst in part (c), the correlation between the basic nature of sodium oxide and the position of sodium in the Periodic Table was often missing or the answers were too vague. In part (e) some candidates were able to complete the word equation correctly. Others gave names which appeared to be a random arrangement of elements and compounds.

- (a) (i) Most candidates gave suitable figures within the ranges so that a trend was followed. More candidates made errors with the values for atomic radius than with the values for thermal conductivity.
- (ii) Some candidates did not make clear whether the direction of the trend in boiling point was decreasing up or down the group. Others tried to link the trend in boiling point to the trend in atomic radius or reactivity, often unsuccessfully.
- (iii) Some candidates gave answers that were identical to the observations about the extent of bubbling for potassium, e.g. 'very rapid bubbling'. Others just suggested 'bubbling' without any further qualification or suggested that there was 'no reaction'. A significant number of candidates gave a description that was not an observation such as 'reacts rapidly'.
- (b) Many candidates realised that an electron is lost when a sodium atom forms a sodium ion. The commonest error was to suggest electron gain. A few candidates suggested that the sodium atom gains a proton.

- (c) Many candidates realised that sodium oxide is a basic oxide but a considerable number thought that sodium oxide is an acidic oxide. The best answers focussed on the position of sodium in the Periodic Table or the fact that sodium is a metal. Common errors included: 'it is a less reactive oxide'; 'sodium gains protons' or 'sodium gains oxygen'.
- (d) Many candidates calculated the relative formula mass correctly. The commonest errors were: to use atomic numbers rather than atomic masses; to use a relative atomic mass of carbon of 16, thus giving an answer of 92, or to not take the number of each atom into account, thus giving an answer of 36.
- (e) A minority of the candidates gained full credit for the word equation. A common error was to suggest that hydrogen is formed instead of water. The salt was sometimes named as an incorrect combination of elements and compounds, e.g. 'sodium sulfuric oxide', 'sodium sulfuric acid'. Other common errors were 'sodium hydroxide', 'sodium sulfite' or 'sodium sulfide'.

Question 8

Some candidates gave good answers to most parts of this question but a considerable minority did not attempt parts (c) and (d). Most candidates were able to read the volume of gas from the graph in part (b). Fewer gave a convincing explanation of why the volume of hydrogen remains the same in part (a) or could name the salt in part (d).

- (a) Some candidates just paraphrased the stem of the question and wrote answers such as 'the hydrogen produced stays the same'. Others described a limit to the maximum amount of hydrogen released without further explanation. A few candidates described correctly that hydrogen chloride was the limiting reagent. Others did not take note of the term *excess zinc* in the stem of the question and suggested that all the zinc had been used up.
- (b) A majority of the candidates deduced the volume of gas correctly. The commonest error was to misread the scale of the graph and give a value of 48cm^3 instead of 38cm^3 .
- (c) Many candidates gained credit for drawing a shallower gradient. Fewer gained credit for estimating the final volume of hydrogen produced when the concentration of hydrochloric acid is halved. Many drew curves which ended with the same overall volume and a significant number drew curves that ended up higher than the 54cm^3 on the y-axis.
- (d) Some candidates gave the correct name of the salt. Others either made up names such as zinc hydrochloric acid or added elements that were not present in either reactant, e.g. oxygen (incorrect answer: zinc oxide) or iodine (incorrect answer: zinc iodide).
- (e) A majority of the candidates realised that the pH value of an acid is below pH 7. A significant number suggested pH 7. Fewer suggested values of pH 9 or pH 13.

CHEMISTRY

Paper 0620/32
Theory (Core)

Key messages

Questions requiring simple answers to calculations were usually answered well, as were questions involving balancing equations and organic definitions.

Questions on more detailed aspects of kinetic particle theory needed to contain a more focused explanation and attention to detail. Candidates needed to think more carefully when constructing their answers.

Some candidates needed more practice on answering questions requiring extended answers, e.g. **Questions 4(a)** and **6(a)**. 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 very important that candidates read the question carefully in order to understand what exactly is being asked. This was particularly the case in **Question 8(b)**. Practice of reading and interpreting data based questions should also be prioritised.

Many candidates needed more practice at answering questions involving the organic parts of the syllabus. The questions that related to practical techniques, namely electrolysis, need to be concentrated on and practised. More specific revision of the chemical tests specified in the syllabus would also be an advantage to many candidates.

General comments

Many candidates tackled this paper well, showing a good knowledge of core Chemistry. Good answers were shown throughout the paper to a number of different questions. Most candidates found parts of every question challenging with the longer questions, in particular, being poorly answered. Nearly all candidates were entered at the appropriate level but there were a few candidates who did not attempt several parts of the question paper. It was evident that many candidates are now using past paper practice as part of their revision program, but more revision is needed on some aspects of the syllabus.

Misinterpretation of the rubric did happen in some cases. The most common was in the question that asked for 'the greatest temperature rise per gram'. However, not reading the question properly was a key factor of some making slight mistakes in their answers. The use of 'chlorine' instead of 'chloride' and 'chloride' instead of 'chlorine' was seen and needs to be practiced. For example, in halogen displacement questions most candidates thought the answer was 'chlorine' not 'chloride'. The balancing of equations indicated that candidates had practiced these as part of their revision from past papers. Definitions from across the syllabus were poorly done and candidates need to concentrate on them both when being taught for the first time and during the revision period.

The vast majority of candidates were able to 'calculate the relative molecular mass'. However, a few candidates used atomic numbers instead of mass numbers in this question. Most candidates could give at least one answer to the comparison of manganese with sodium. Data handling type questions could have been answered better. Candidates were much better at estimating melting points and densities.

Dot-and-cross diagrams were drawn very well as in the 'dot-and-cross diagram for chlorine'. Candidates needed to be more explicit when talking about certain concepts and not use the words 'it' and 'they' to answer questions as this can lead to unclear responses. Some candidates wrote their answers as short phrases or bullet points. Candidates are less likely to write vague statements or contradict themselves if this is done.

Comments on specific questions

Question 1

Candidates tackled this question reasonably well; some struggled with parts **(a)(i)** and **(ii)**.

- (a) (i)** A very small proportion of candidates answered this question correctly. Candidates did not seem to know that chlorine was the correct answer, with many thinking the answer was ammonia.
- (ii)** This question proved challenging. Candidates would have benefitted from revising the chemical tests.
- (iii)** This was a well answered question – only a few candidates thought it was helium.
- (iv)** The products of incomplete combustion had not been revised enough and lots of different answers were seen here.
- (v)** Candidates did not seem to know the correct answer here and ethane was seen quite a few times.
- (b) (i)** This was a well answered question with most candidates realising that diatomic meant two atoms but two atomic was not allowed. Two or more atoms was also seen in a few instances.
- (ii)** This was one of the least well answered questions on the paper. Only a very small proportion of candidates knew the definition for this, with it being something that needs to be concentrated on when teaching this part of the syllabus.
- (c)** This was a very well answered question. Dot-and-cross diagrams have obviously been worked on. Candidates needed to make sure that they counted how many electrons were in the outer shell when they finished this question.

Question 2

Candidates answered this question well. The part question that most struggled with was **(c)(i)**.

- (a) (i)** Calculators are a must for this type of question. Where candidates did not quite get the correct answer, calculator error was probably the cause so candidates need to be encouraged to check their keying in of numbers more than once on the calculator.
- (ii)** Only a very small minority of candidates did not achieve this mark.
- (b) (i)** This was a poorly answered question where some candidates thought they 'caused cancer' or were 'poisonous/toxic'. Candidates need to learn at least one adverse effect for any of these gases that are mentioned in the syllabus.
- (ii)** This was a very well answered question. Most of the candidates that were entered for this paper can now balance equations with a degree of confidence.

- (iii) More practice is needed on naming salts from formula. NO_3^- is nitrate not nitrite, as some candidates thought. Some candidates thought that NO was nobelium and had obviously wasted time looking through the Periodic Table to find it. Candidates need to know that capital letters are new elements. NO is nitrogen and oxygen in this case. Sodium nitroxide was also seen in quite a few different instances.
- (c) (i) This question was not answered well. Some candidates thought that the answer was to do with having enough solid dissolved in water, which showed that they had not read the first part of the question which said that the 'petrol contains saturated hydrocarbons'. Some candidates wrote about single bonds but forgot to mention the word 'only'.
- (ii) Many candidates achieved at least one mark on this question. Candidates needed to realise the word 'only' must be used again and that a hydrocarbon is a 'compound'. Some candidates thought that oxygen was present.
- (d) This part question was well answered in many cases. The alkanes needed to be added together, which most candidates could do. Not making slight mistakes on calculators and repeating a calculation needs to be practiced.

Question 3

This proved to be a challenging question for most candidates. The structure of the alcohol group in (a)(ii) was a problem to most candidates as well as (a)(iv) the polymer definition.

- (a) (i) Many candidates did get five types of element but some missed out one element and got four – probably not spotting the sulfur. More practice is needed in answering this type of question.
- (ii) This question was not answered very well by most candidates, with many candidates circling carbons as well as the 'OH' group. Many candidates also circled the 'OH' on the carboxylic acid which was wrong. Some candidates did not attempt this question at all.
- (iii) This was a well answered question. Candidates had obviously been taught this well and had revised it in readiness for the examination.
- (iv) Most candidates did not know this polymer definition and more practice is needed here.
- (b) (i) This was a poorly answered question. Typical properties of acids were looked for, which candidates did not know. 'Reacts with sodium hydroxide' or 'reacts with a carbonate' were correct answers. Candidates did not put these down and instead talked about melting and boiling points. Some candidates did get 'pH below 7'.
- (ii) Not many candidates achieved the mark here. Other groups were seen like alcohols and alkenes. Candidates needed to practice the drawing of molecules. Some candidates did get the correct answer but then others were nearly there but forgot the bond between the oxygen and hydrogen.
- (c) (i) Many candidates worked out it was a solid. Some candidates realised that -120°C was below -114°C as the justification for the solid answer. However, some candidates got mixed up with negative numbers and how they work for temperatures and thought the temperature was above the melting point. Many candidates had obviously practiced this type of question as part of their preparation for the examination.
- (ii) The second blank proved to be the hardest with not many candidates writing down 'ethene' here. Candidates need to be reminded not to over write the 'e' and the 'a' in an alkene and alkene, as answers must be unambiguous. It is better for a candidate to cross the work out and rewrite it. Candidates must be encouraged to do this as part of their examination technique. More revision on the manufacture of ethanol needs to be done.

Question 4

Most candidates did well on this question, especially on **(c)(ii)**, the balancing of the equation. Candidates struggled on **(c)(i)**, showing that chemical tests needed to be revised more. There was an improvement on answering the 'kinetic particle model' question but candidates needed to mention the term *molecules* or *particles* in their answer.

- (a)** There was some improvement in the answering of this 'kinetic particle model' question. However, some forgot to mention the term *particles* or *molecules* in their answers. Further practice on this type of question would be very helpful.
- (b)** Candidates answered this question well. Some got mixed up with the definition for oxidation and put the definition for reduction instead. The gain and loss of electrons was also occasionally mixed up.
- (c) (i)** Candidates found this part challenging. The chemical tests proved hard for candidates to recall. More revision time should be used learning these tests and frequent revisiting in class would be very advantageous. This part of the syllabus needs more time given to it.
 - (ii)** The balancing of the equation was answered very well by most candidates.
- (d)** Most candidates could get the metals in the correct order. A few candidates used the term *metal* in one of the boxes, which showed that they had not processed the boxes correctly.
- (e)** Not many candidates gained full credit here. Some candidates did not read the question properly and talked about 'going down the group'. In this sort of question, it is better for the candidates to think about transition metal properties rather than just ordinary metal properties. It is also better for candidates to be taught as part of exam technique to name the metals they are talking about rather than calling them 'it' as sometimes it is hard to decide which metal is being talked about. All responses must be unambiguous.

Question 5

Candidates struggled with part **(a)(i)** and did not know how to collect the gas from the electrodes. They also struggled with **(a)(iii)**, as they forgot the fact that it was an aqueous solution.

- (a) (i)** Only very few candidates got this question correct. This was probably the most challenging question on the paper and lots of candidates did not answer it. Candidates did not realise that two test-tubes placed over the two electrodes was sufficient. Candidates who did attempt the question tried to cover the two electrodes with the same vessel (for example a beaker) and therefore were not awarded the mark. Candidates who were experienced with the practical aspects of this course were more likely to perform well here.
 - (ii)** The vast majority of candidates were able to access and answer this question. A common incorrect response was 'canode'.
 - (iii)** This was a poorly answered question, with candidates not reading the question properly and not noticing the term *aqueous*. This meant that 'sodium' was given as the main product at the negative electrode, which was incorrect. Some candidates gave 'chloride' instead of 'chlorine'.
 - (iv)** Some candidates did get the correct element here. Other candidates thought that other reactive elements like copper could be used. Candidates would have benefited from more revision of electrolysis experiments.
- (b) (i)** Most candidates got the correct answer here. Candidates must always ensure that they write down the correct units, as '150 cm³' was an incorrect answer.
 - (ii)** Very few candidates achieved the correct answer here – most of them thinking that the melting point 'increased'.
- (c)** This practical based question was poorly answered. 'Crystallisation' or 'evaporation' are the main answers that were seen in some cases but many candidates did not use those words successfully.

Question 6

Part (a) was answered well by most candidates. Many candidates did not know the in-depth definition of the term *isotopes* in part (b).

- (a) This was a very well answered question, especially by the candidates who went on to gain the higher marks on this paper. These candidates were able to easily answer about the numbers of protons, neutrons and electrons in the stated isotope and also to say where the sub-atomic particles were in the atom. Some candidates did misinterpret this question by thinking the position meant where the sub-atomic particles were in terms of how the symbol is written; for example 'protons are found at the bottom of the symbol'.
- (b) Candidates did not seem to know the in-depth definition of the term *isotope*. Some could say that there are the 'same numbers of protons but different numbers of neutrons' but forgot to use the fact that they are 'atoms'. More revision of definitions was needed here.
- (c) Candidates needed to read the question carefully, as it was asking for 'one industrial use' – many candidates put a 'medical' use of radioactive isotopes.

Question 7

Parts of this question were answered well including (a)(i) and (c). Candidates struggled with the 'density of chlorine' in part (a)(ii) and they had not mastered the displacement word equations from the halogens part of this course in part (b).

- (a) (i) Most candidates could identify the trends in melting points and densities of the halogens and they put the correct figures into the table. Candidates need to be discouraged from using ranges of numbers because these usually fall outside the allowed parameters. It is not always a good idea for candidates to use numbers too near to the lower or upper parameter. It is best to use numbers in the middle. Not many candidates realised that the colours got darker down the group.
- (ii) This was a poorly answered question by most candidates, as they did not realise that chlorine is a 'gas' at room temperature and that is why its density is lower than that of bromine and astatine.
- (iii) Some candidates needed to expand their answer. 'Increases' was not enough, as the trend was not wholly identified. 'Increases down the group' was the appropriate answer and candidates must be encouraged to practice these questions more.
- (b) This question was poorly answered. Candidates struggled with the products of a halogens displacement reaction. 'Potassium bromine' was seen, as well as 'bromine iodide'. More practice is needed when studying this part of the course. Not many completely correct answers were seen here.
- (c) Candidates were well practiced at this relative molecular mass question, showing much practice and revision. Not many wrong answers were seen here. Some candidates did use atomic numbers instead of masses.

Question 8

Candidates answered parts (e)(i) and (iii) well but struggled with parts (a) and (b).

- (a) Some candidates got both answers correct. Candidates struggled with the practical aspects and this is something that needs to be concentrated on. Typical wrong answers were 'same amount of fuel' and 'same starting temperature'. Candidates were better to 'keep the distance of the flame to the can the same' and the 'same volume of water'.

- (b) This question was very poorly answered by all candidates. Most candidates used the answer 'C' which was wrong – they did not spend enough time on the question and read it carefully enough. Candidates needed to give the 'greatest temperature rise per gram'. It was evident that candidates did not spend enough time reading the question properly.
- (c) It is a good idea for candidates to know at least two uses of the substances mentioned for uses in the syllabus. It was evident that some candidates only knew that ethanol was used as a 'fuel', as they used this in their answer even though it was mentioned at the start of the question. This is a good reason to know at least two uses.
- (d) (i) Candidates did get mixed up with this question and lots of different answers were seen. If a straight forward word equation for complete combustion had been asked for, then most candidates would have achieved the two marks but in this question a little bit more reading and thinking was needed.
- (ii) Using the information in the diagram to explain the answer was a challenge for most candidates. Explaining energy profile diagrams needs to be practiced more. Pointing out which has the most energy, reactants or products, is a good starting point here.
- (e) (i) The definition of the term *alloy* was generally good. Candidates had learned the definition and obviously practiced it. Some candidates thought it was a 'combination' of metals and a few thought that an alloy just had non-metals in it.
- (ii) Not many candidates could answer the 'arrangement' part of this question correctly and talked 'tightly packed' instead of a 'lattice' or 'regular' arrangement. More candidates could get the 'type of motion' part with the correct answer of 'vibration'.
- (iii) This last question was very well answered with candidates able to talk about the fact that stainless steel does not corrode or iron does. Candidates must guard against talking about iron being 'corrosive'.

CHEMISTRY

Paper 0620/33
Theory (Core)

Key messages

Many candidates needed more practice in questions involving qualitative analysis.

It is important that candidates read questions carefully in order to understand what is exactly being asked.

Many candidates needed more practice in memorising the meaning of chemical terms such as *compound* or *hydrocarbon*.

The balancing of simple equations and extraction of data from tables was generally well done.

General comments

Many candidates tackled this paper well, showing a good knowledge of core Chemistry. Nearly all candidates were entered at the appropriate level. Most candidates attempted all parts of each question. The exceptions were **Questions 4(a)(ii), 5(d), 7(a)(i), 7(a)(i), 7(b), 7(c) and (8)(e)** where a significant number of candidates did not respond.

Many candidates needed more practice in questions involving qualitative analysis. For example, very few candidates knew the test for water using cobalt chloride (**Question 3(b)(ii)**), the test for an unsaturated hydrocarbon (**Question 4(a)(ii)**) or the test for bromide ions (**Question 5(f)**).

Some candidates needed more practice in reading and interpreting questions. The rubric was misinterpreted or ignored by some candidates. In **Question 2(a)(i)** the words 'on health' were ignored. In **Question 3(g)**, many candidates did not refer to the equation as instructed in the stem of the question, whilst in **Question 4(b)(iii)** some candidates did not choose a 'use in industry' as asked for by the question. In **Question 6(a)** a considerable number of candidates did not write about the position of the sub-atomic particles in the atom.

Many candidates needed more practice in answering questions involving chemical terms without contradicting themselves. For example, in **Question 1(b)(ii)**, many candidates wrote about single atoms or compounds rather than elements and in **Question 6(c)** some candidates suggested that nucleons were only protons or the mass of the element.

Some candidates needed more practice in answering extended questions such as **3(a)** (diffusion) and **6(a)** (position and number of sub-atomic particles).

Questions involving general chemistry, including organic chemistry, were generally tackled well by many candidates. Many candidates were able to balance simple equations and extract relevant information from tables of data. Others needed more practice in naming salts, describing how a soluble salt can be separated from an insoluble salt and in understanding the reactions of halogens with halide ions.

Comments on specific questions

Question 1

Most candidates identified two of the gases correctly in part (a) but only a minority of the candidates identified the gas that forms an acidic solution in part (i) or identified the monatomic gas in part (ii). In part (b) most candidates identified two elements in (b)(i); fewer gave a convincing explanation of the term *element* in (b)(ii). The dot-and-cross diagram in part (c) was generally well answered.

- (a) (i) A minority of the candidates identified hydrogen chloride. The commonest error was to suggest ammonia. The next most common error was to suggest ethene.
- (ii) A minority of the candidates correctly identified helium as being monatomic. The commonest error was to suggest hydrogen. Other common errors were ammonia or methane.
- (iii) Some candidates correctly identified nitrogen as forming 78% of dry air. Hydrogen was the commonest incorrect answer. The next most common error was methane.
- (iv) Some candidates correctly identified methane as the main constituent of natural gas. Hydrogen was the commonest incorrect answer. Hydrogen chloride or ammonia were other errors seen.
- (v) Many candidates were able to identify the molecule containing 14 protons. The commonest error was to suggest hydrogen chloride.
- (b) (i) Nearly all the candidates were able to identify two elements from the list.
- (ii) A minority of the candidates gave a good definition of the term *element*. Many answers were too vague to give credit, e.g. 'a set of one atom', 'two or more atoms together', 'a product in the Periodic Table'. Better performing candidates wrote about substance containing only one sort of atom. A significant number of candidates wrote 'the same type of molecule', which could apply to ammonia or hydrogen chloride'.
- (c) Many candidates drew a correct dot-and-cross diagram for hydrogen chloride. Some only gave a bonding pair of electrons. Common errors included: too many electrons on the chlorine atom; one or no bonding electrons or addition of extra non-bonding electrons on the hydrogen atom.

Question 2

This question was generally the best-answered on the paper. Many candidates gained full credit for parts (a)(i), (b) and (c). Fewer gained full credit for comparing the composition of the exhaust gases in part (a)(ii) or for giving one adverse effect of sulfur dioxide on health in part (a)(ii).

- (a) (i) Most candidates gave the correct answer. The commonest errors arose from not including all the figures in the addition.
- (ii) Many candidates gave at least two differences in the composition of the exhaust gases. Others wrote statements that were too vague, e.g. 'there is a greater volume of gases, which are not harmful in petrol' or 'there is more volume of gases in the petrol engine than the diesel'.
- (iii) Some candidates gave a correct effect of sulfur dioxide on health. Others did not focus on the word 'health' in the stem of the question and gave answers such as 'hazardous for the environment' or 'acid rain'. Some answers were incorrect because they either referred to disease or cancer. A significant number of candidates appeared to muddle the effect of sulfur dioxide with that of carbon monoxide.
- (b) Nearly all the candidates filled in the gaps in the sentences correctly. The commonest errors were 'density' or 'crystallisation' (instead of distillation), 'poly(ethene)' (instead of kerosene) and 'poly(ethene)' (instead of boiling).
- (c) Most candidates were able to balance the equation. The commonest errors were $3(\text{H}_2\text{O})$ and $2(\text{CO}_2)$. Those who made errors, generally gave an incorrect balance for the carbon dioxide. A significant number of candidates gave a balance of $2(\text{H}_2\text{O})$ and $2(\text{CO}_2)$.

Question 3

Parts **(b)(i)**, **(d)** and **(f)** were answered well by many candidates. Many did not give detailed enough answers to part **(a)** (diffusion) and **(g)** (reduction). Few knew the test for water using anhydrous cobalt chloride (part **(b)(ii)**). Some candidates were able to give three differences between cobalt and lithium in part **(e)**. Others wrote answers that were too vague.

- (a)** Some candidates recognised that diffusion was occurring. Few explained diffusion in terms of the particles moving randomly from areas of higher concentration to areas of lower concentration. Many just described the cobalt chloride moving or the colour moving. A minority of the candidates did not recognise the physical process of diffusion and described chemical reactions in the solution.
- (b)(i)** Many candidates recognised the symbol for a reversible reaction. Common errors included: 'balanced equation'; 'same reactants and products' or 'turns into products'.
- (ii)** Few candidates knew the test for water using anhydrous cobalt chloride. Many confused it with the test for water using anhydrous copper sulfate, often giving the colours the wrong way round. Others confused it with the bromine water test for unsaturation. Common incorrect colours for the anhydrous cobalt chloride included orange, red and white. Common incorrect colours for the hydrated cobalt chloride included brown, blue and colourless.
- (c)** Some candidates wrote the correct molecular formula. Others disadvantaged themselves by writing the formula as $\text{CO}_2\text{C}_8\text{O}_8$. Other common errors were: $2\text{CoC}_8\text{O}_8$, $\text{CO}28\text{CO}$ or $2\text{Co}8\text{C}8\text{O}$.
- (d)** Some candidates gave the correct order of reactivity but many reversed the order completely. Others seemed to rely on their existing knowledge of the reactivity series rather than using the information in the table. This was obvious from those candidates who wrote down lists of relative reactivity either next to the question or on one of the blank pages.
- (e)** Some candidates gained credit for correct comparisons of the properties of cobalt and lithium but few gained full credit. Many described properties that were common to both metals, e.g. conductivity. Some thought that one was a metal and the other was a non-metal or described their relative positions in the Periodic Table. A significant number of candidates did not mention which metal they were writing about. It was assumed that if no name was mentioned, that the answer referred to cobalt. Many candidates did not score because they wrote about electronic structure, number of protons or physical state or did not compare properties sufficiently well, e.g. cobalt is malleable (rather than less malleable than lithium). Others wrote statements that were too vague, e.g. cobalt is heavier than lithium.
- (f)** Many candidates balanced the equation correctly. The commonest incorrect answer was to suggest $2(\text{CoO})$.
- (g)** Many candidates gave a definition of reduction but did not apply the concept of reduction to the equation. Others described the equation without explaining how it was a reduction. Many candidates described the cobalt losing oxygen rather than the cobalt oxide losing oxygen. Others wrote answers that were too vague, e.g. 'the oxygen and cobalt split apart'.

Question 4

Parts **(a)(i)**, and **(b)(ii)** were answered well by many candidates. Many did not know the test for an unsaturated compound in part **(a)(ii)** and many candidates did not respond to this part. Better performing candidates were able to draw the structure of ethanol in part **(b)**. A minority of the candidates gave a suitable use of ethanol in industry in part **(b)(iii)** and few could explain the energy level diagram in part **(b)(iv)** or state the name of two products formed when ethanol burns in a limited supply of air in part **(b)(v)**.

- (a)(i)** Many candidates identified the $\text{C}=\text{C}$ bond as being responsible for unsaturation. The commonest errors were to refer to either the OH or CH_2 group or to suggest that there were 'missing bonds'.
- (ii)** A minority of the candidates knew the correct colour change when aqueous bromine reacts with an unsaturated compound. Others either reversed the colours (colourless to orange) or guessed the colour of the product, green, white, orange or blue being commonly seen. Common incorrect colours for aqueous bromine were red or blue. A few candidates suggested white or transparent for the colour of the product, which was not accurate enough.

- (iii) Some candidates gave good answers relating the temperature of -120°C to its position between the melting point and the boiling point. Most candidates who chose the correct state (liquid) only wrote about one of the fixed points, e.g. 'liquid because it is above the melting point'. Others gave vague answers such as: 'the melting point is 9 degrees away' or 'it's about to reach its boiling point'.
- (b) (i) A minority of the candidates drew the correct structure of ethanol. The commonest errors were to show the presence of a double bond, to draw the structure of ethane or to draw the carbon attached to the OH group with five bonds.
- (ii) Most candidates gained at least two marks. The commonest errors were salt (instead of sugar), 300°C (instead of 30°C), sugar (instead of enzymes) and electrolysis (instead of distillation).
- (iii) Very few candidates gave a suitable use of ethanol in industry. Many suggested its use as a fuel or oil despite the word 'fuel' being in the stem of the question. Others gave non-industrial uses such as 'rubbing alcohol', 'for drinking' or 'preservatives'. A significant number of candidates thought that ethanol is used in fertilisers.
- (iv) Many candidates did not gain credit because they did not refer to the diagram and only gave a definition of an endothermic reaction. Others gave vague answers such as 'energy goes from top to bottom' or just referred to the equation.
- (v) Many candidates gained only one mark because one of the products suggested was water, which is in the stem of the question. Other common errors included hydrogen or oxygen. A few suggested methane.

Question 5

Some candidates responded well to this question, especially in parts (a) and (f). Others suggested that gases were given off during the electrolysis in part (b) or that elements other than those present in the electrolyte were formed. Few gave correct descriptions of the salt preparation in part (c) or identified the orange-brown substance in part (d). The colour of silver bromide in part (e) was known by very few.

- (a) Many candidates were able to give the name of the positive electrode. Common incorrect answers included 'cnathode, pathode, anion and graphite'.
- (b) Some candidates gained one mark but few gained both marks. Some wrote lead(II) (equivalent to Pb^{2+}) instead of lead. Others suggested that gases such as hydrogen and oxygen were produced, perhaps thinking that the electrolyte was an aqueous solution. A significant number of candidates either gave electrode products that did not relate to the electrolyte, e.g. copper, or gave the names of compounds, e.g. lead bromide.
- (c) A minority of the candidates gave a suitable method for getting crystals of lead bromide from the mixture. Many either did not add water or added acids instead of water. The process of filtration was absent from many answers. Many suggested evaporating the solids formed. Others did not explain the process of crystallisation sufficiently and wrote vague answers such as 'let the solution rest'.
- (d) Some candidates identified bromine as the element responsible for the orange-brown colour. Others suggested sodium bromide, sodium, an inter-halogen compound or sodium chloride plus bromine.
- Very few candidates gave a suitable reason and some referred to chlorine being reactive instead of comparing the reactivity with bromine. The most common error was to compare the reactivity of chlorine with sodium or bromide ions. A significant number of candidates wrote vague statements about electrons or the balance of the equation.
- (e) Few candidates knew the colour of silver bromide. The commonest incorrect answers were white or yellow.
- (f) A majority of the candidates recognised that an electron is gained when a chloride ion is formed from a chlorine atom. The commonest incorrect answer was to suggest a proton.

Question 6

Some candidates gave good answers to part **(a)** (atomic structure). Others did not respond to the part of the question asking about the position of the subatomic particles. Many candidates gained at least one of the two marks available in part **(b)**. Fewer could describe the term *nucleon number* satisfactorily in part **(c)**.

- (a)** The location of electrons was not made clear by many candidates. Statements such as ‘they are in energy levels’ or ‘in shells’ were not sufficient to gain the mark. Many candidates suggested that ‘the electrons are outside the atom’, rather than outside or surrounding the nucleus. Many gained only three marks because they identified the correct number of electrons, protons and neutrons but did not describe their position. Others described the position by trying to relate it to the isotopic symbol, e.g. ‘the proton number is lower’ or ‘the neutrons plus protons are up’.
- (b)** Many candidates gained at least one mark for a correct statement about isotopes. The commonest error was to tick the top box (isotopes of the same element have different numbers of protons).
- (c)** A minority of the candidates realised that the term *nucleon* refers to both neutrons and protons. The commonest errors were: ‘the number of neutrons’, ‘the mass of the atom’, ‘the number that the element has’ or ‘the number in the nucleon’.

Question 7

Many candidates performed reasonably well in this question, especially in parts **(a)(i)** and **(d)**. In part **(b)** some candidates could write the electronic structure of sodium correctly. Others did not appear to understand the meaning of this term. Part **(c)** was least well answered, with many candidates writing vague answers for the explanation of alkalinity and the use of indicators to show that a solution is alkaline.

- (a) (i)** Most candidates gave suitable figures within the ranges so that a trend was followed. More candidates made errors with the values for melting point than with the values for relative hardness.
- (ii)** Many candidates gave suitable observations mentioning slow bubbling. The commonest incorrect answer was ‘no reaction’. Others wrote ‘bubbling’ (unqualified) or wrote general comments about reactivity instead of giving observations.
- (b)** Few candidates were able to deduce the electronic structure of sodium. Many just wrote Na or gave the total number of electrons. A few candidates wrote structures in the form $1s^22s^2$, etc. These candidates almost invariably gave the incorrect electronic structure.
- (c) (i)** Some candidates focussed on the sodium hydroxide or hydroxide ions being responsible for the alkalinity. The commonest error was to suggest that the hydrogen is alkaline in nature. Many candidates wrote answers about neutralisation or the loss of atoms or electrons.
- (ii)** Many candidates were able to select a suitable indicator, Universal Indicator generally being the indicator of choice. Fewer were able to give a correct colour in alkaline solution, yellow, green or red being the colours most often suggested.
- (d)** Most candidates calculated the relative formula mass correctly. The commonest incorrect answers were 20 (using atomic numbers) or 35 (not multiplying the number of hydrogen atoms by 4).

Question 8

Many candidates gave good answers to part **(a)** and **(c)**. Fewer were able to describe fully how the apparatus was used in part **(b)** or to relate the size of the pieces of calcium carbonate to the rate of reaction in part **(d)**. In part **(e)** many candidates either named the salt incorrectly or gave products other than carbon dioxide and water.

- (a)** Many candidates identified the measuring cylinder. The commonest incorrect answer was ‘test-tube’. References to beakers or flasks were not uncommon.

- (b) Few candidates gave convincing descriptions about how the apparatus could be used to measure the rate of reaction. A common error was to state 'measure the volume of the substance' without referring to which volume was to be measured. A significant minority thought that it was the volume of the acid and zinc that should be measured. Many just referred to liquid levels without reference to the volume of gas. Others suggested counting bubbles or gave answers that were irrelevant to the question, e.g. 'the more the gas, the higher the rate of reaction'. Most candidates that gained a mark did so for a reference to time rather than measuring the volume of gas.
- (c) Many candidates recognised that the reaction rate would be less or the reaction would be slower. Others did not gain the mark because their answers were not comparative, e.g. the reaction is slow. A significant number of candidates wrote about the reaction decreasing, rather than the reaction rate decreasing.
- (d) Some candidates were able to relate the size of the pieces of calcium carbonate to the rate of reaction. The commonest error was to suggest small pieces (medium rate of reaction), powder (slowest reaction) and large pieces (fastest reaction). Some candidates wrote numbers in the left hand column instead of sizes.
- (e) Very few candidates gained two marks for this question. The commonest errors were to write 'calcium hydroxide' or 'salt' instead of calcium chloride. Hydrogen was often written instead of carbon dioxide or water. A few candidates wrote sulfur instead of sodium. Others suggested organic compounds.

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Paper 0620/41
Theory (Extended)

Key messages

Candidates should be reminded to use precise terms and words where applicable. For example, there was frequent incorrect use of terms in **Question 1(a)** where it was frequently written that two atoms make a compound or in **6(b)** where it was frequently written that one element replaces a molecule.

Candidates should be reminded that if a specified number of characteristics of a substance is asked for, such as **Questions 2(e), 3(a), 5(a)(ii), 5(b)** and **5(e)(iii)**, then no more than this number should appear in the answer; any incorrect characteristics given may be viewed as a contradiction to the correct responses.

Better performing candidates had good examination techniques, such as underlining of command words in the questions. Candidates should be encouraged to read questions carefully.

Candidates should look to make answers concise and keep to the space available. Better performing candidates made use of simple bullet points rather than long paragraphs; this was seen frequently in **Question 3(b)**.

General comments

Working should be shown in calculations and this working should be set out so that it can be followed. This will allow method marks to be awarded in calculations even if the final answer is incorrect.

When a question asks for a *chemical equation* a word equation will not be accepted. Where a *word equation* is asked for, candidates should refrain from writing a chemical equation as these are more difficult and increase the likelihood that an error will be made.

Comments on specific questions

Question 1

- (a) Most candidates were able to explain the term *compound*. Candidates who performed less well showed a lack of understanding of the linking of basic terms such as *atoms*, *molecules* and *elements*.
- (b) Most candidates knew this straight forward method of separation. Many omitted to attempt the dissolving stage and it was evident that a significant number of candidates assumed that evaporation and crystallisation were separate stages.
- (c) (i) The name of the condenser was well known; a minority realised that cooling water needs to enter at the lower aperture only.
- (ii) Most candidates included a bung in the diagram accompanied with the logical response that it prevented alcohol vapours escaping. Some candidates opted to draw a thermometer but often left substantial gaps either sides of it. The need for a thermometer was less well understood.
- (iii) A minority of candidates knew that the flammability of alcohols was the reason to avoid using a Bunsen burner. Several common misconceptions, such as a lack of temperature control of the mixture or possible cracking of the flask, were seen.

- (iv) Some excellent answers were seen; there were also some imprecise answers with much confusion between evaporation, boiling and melting. Such responses indicated that the candidate was not familiar with the use of a water bath and did not realise that a water bath could not be heated to the temperatures needed to boil the alcohols. A common error was to assume that the boiling points of alcohols **C** and **D** were too close together.

Question 2

- (a) Most candidates were able to determine that element Z must be calcium; neon was a commonly seen error.
- (b) Nearly all candidates indicated knowledge of what periods are in the Periodic Table; many mis-counted and assumed *Fl* was in Period 6.
- (c) Most candidates were able to use the copy of the Periodic Table provided to spot that *Fl* was a Group 4 element and would have four outer shell electrons.
- (d) (i) The term *radioisotopes* was not well known. The most common error was to attempt a definition of isotopes.
- (ii) Most candidates answered this correctly.
- (e) (i) Most candidates were able to give two physical properties that are typical of metals. Many candidates opted to give more than two properties. This was not asked for and some candidates contradicted previously correct responses.
- (ii) Many candidates did not understand the difference between physical and chemical properties and gave physical properties as the answer. Better performing candidates knew that the oxide of a metal would be basic.

Question 3

- (a) The correct answer, hot air, was seldom seen. Oxygen was the popular wrong answer. Many other incorrect answers were seen, ranging from iron ore to zinc blende.
- (b) There were some well written, well-structured and suitably detailed answers. Many candidates clearly worked hard to learn this industrial process thoroughly. Candidates who performed less well found this process difficult to recall or difficult to sequence correctly. Candidates are advised to use a bullet point approach and to use short sentences.
- (c) Carbon was well known as the main impurity of iron extracted from the blast furnace; very few stated that oxygen needs to be blown **through** molten iron and also did not realise the significance that carbon dioxide was able to escape as a gas.

Question 4

- (a) Relatively few candidates realised that the definition was in fact that of relative atomic mass. 'Mole', 'Avogadro's constant' and 'relative molecular mass' were popular alternatives.
- (b) The origin of the different terms was not well known with most candidates not appreciating the ionic and covalent nature of the two substances. A common mistake was to focus on butane being organic and KF being a compound.
- (c) Many candidates were able to calculate the correct answer to this demanding question but having arrived at a relative molecular mass value of 38, did not realise that this gas must be fluorine (F_2). Common incorrect identities included strontium and potassium.

- (d) Candidates were not confident in the mathematical method to find an empirical formula. A significant proportion of candidates rounded calculated values too soon in the calculation, leading to incorrect whole number ratios of moles. Many candidates did not calculate the mass of oxygen in the compound as an initial step of the calculation, but credit could still be earned for the rest of the work provided clear working out was shown.
- (e) Candidates found this question challenging. Having determined the molecular formula of the oxide or the relative formula mass of P_2O_3 or even P_4O_6 , they went on to do irrelevant calculations instead of determining the relative molecular mass.

Question 5

- (a) (i) The term *catalyst* was familiar to candidates as something which increased the rate of a reaction but remained unchanged at the end of the reaction. It is not strictly true that catalysts do not take any part in the reaction, the key point is that they remain unchanged at the end of the reaction. Some candidates assumed catalysts had to be enzymes.
- (ii) Many candidates repeated properties given in the question such as ‘forms coloured ions’ or gave physical properties instead of a chemical property which was asked for.
- (b) The physical properties given were usually correct; some candidates did not appreciate that this question referred to physical properties of transition metals, which were not shared with Group 1 metals and gave the same general physical properties of metals as already seen in **2(e)(i)**.
- (c) (i) The products of this reaction were often correct but a significant number of candidates omitted state symbols or erroneously assumed $ZnSO_4$ to be (s).
- (ii) This part was not well-attempted. Where candidates did realise where the activation energy arrow should go, many arrows were of the wrong length or were double-headed.
- (iii) The vast majority identified the reaction as being exothermic but the reason was often inadequately stated or was flawed. One common flaw was to include comments about the energy needed for bond formation or the energy released when bonds are broken.
- (d) Very few correct energy profiles for a catalysed reaction were seen.
- (e) The electrolysis of aqueous copper sulfate was well known.
- (i) Most candidates attempted an ionic half-equation and copper was frequently seen as the product. State symbols were often omitted.
- (ii) Non-observational responses such as ‘copper is formed’ were frequently given. Candidates should be aware that observations need two parts: firstly, the colour, secondly the state of the substance. In this case, ‘pink solid’ was expected.
- (iii) Better performing candidates knew that the blue colour of the solution would fade and that effervescence would also take place. Candidates should remember that a colourless gas cannot be seen so is not an observation.
- (iv) Better performing candidates realised that a green gas would be seen. Non-creditworthy responses included ‘chlorine is made’, which missed out the key details of what would actually be seen.

Question 6

- (a) The meaning of the term *hydrocarbon* was well known.
- (b) Better performing candidates knew that *saturated* referred to all bonds being single. To say ‘it has single C–C bonds’ is not correct as alkenes (apart from ethene and propene) have at least 2 C–C bonds. Some candidates incorrectly wrote about saturated solutions.
- (c) (i) Many candidates understood the principle of substitution but did not adequately describe the process in terms of one atom taking the place of another atom.

- (ii) The need for ultraviolet light (or sunlight) was known by many candidates
 - (iii) It was expected that candidates would give the products of mono-substitution ($C_2H_5Cl + HCl$) but frequently di-substituted $C_2H_4Cl_2$ was given along with H_2 , which indicated some understanding of the idea of substitution.
- (d)
- (i) Candidates were aware of the concept of an addition reaction but did not state the key point that only one product is formed. As an alternative, the idea of the $C=C$ double bond being broken was accepted. Imprecise answers included simple statements such as 'because bromine is added to the molecule' and these could not be credited.
 - (ii) Candidates found this a challenging question. A large number of the candidates who gave a dibromo- product attached the bromines each to C_1 and C_3 whereas others attached both bromines to the same C atom. Some drew dibromoethene.
- (e) Most candidates realised that but-2-ene was the unbranched isomer required and could successfully draw and name the isomer. Some correct structures were shown which were not fully displayed.
- (f)
- (i) Poly(ethene) was known by most of the candidates.
 - (ii) The completion of the equation was reasonably well attempted. Better performing candidates included continuation bonds bisecting brackets and the use of a subscript 'n'.
- (g) Most candidates were able to draw at least one amide link but very few were able to orientate both amide links in the correct alignment for the part of the protein shown.
- (h) Better performing candidates recognised the ester as ethyl butanoate and consequently gave the names of the reactants as ethanol and butanoic acid. Only a small minority of candidates realised that water is also a product. Some candidates did not notice that a **word** equation was asked for.

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<p>Paper 0620/42 Theory (Extended)</p>
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Key messages

- Candidates are advised to write equations on one line as opposed to starting on one line and carrying on the next line. In such cases, it is often unclear what the products are and what the reactants are.
- Candidates should be aware of the precise meaning of the terms *electrolysis*, *electrolyte* and *electrode*. Although they all start with the same letters, they have very different meanings.
- Candidates should understand the meanings of the terms *filter*, *filtrate* and *residue* as applied to the process of filtration.

General comments

Working should be shown in calculations and this working should be set out so that it can be followed. This will allow method marks to be awarded in calculations even if the final answer is incorrect.

When a question asks for a *chemical equation* a word equation will not be accepted. Where a *word equation* is asked for, candidates should refrain from writing a chemical equation as these are more difficult and increase the likelihood that an error will be made.

Comments on specific questions

Question 1

Candidates generally answered this question well.

- (a) Evaporation was occasionally seen, rather than distillation.
- (b) & (c) Candidates performed well on these questions.
- (d) Incorrect answers included cracking and fermentation.
- (e) Spelling occasionally proved to be a problem but phonetic answers were credited.

Question 2

Candidates generally answered this question well and were familiar with the Period 3 elements.

- (a) & (b) There were no common incorrect answers.
- (c) Magnesium was seen occasionally but was incorrect as it does not need to be stored in oil.
- (d) Argon was seen occasionally.
- (e) Argon was well known as a gas that provides an inert atmosphere in lamps.
- (f) Some candidates were under the impression that they had to identify **two** elements rather than one element that can form two oxides.
- (g) Sulfur was seen occasionally rather than phosphorus in phosphate fertilisers.

Question 3

This was answered extremely well by the majority of candidates. The charge on the iron(II) ion was a common omission. The number of electrons was occasionally given as 16 or 17. Ba was occasionally given as an alternative to Fe.

Question 4

(a) Br was often seen as the formula of bromine. K_2 was occasionally seen as potassium (the $_2$ being used to balance the equation). The formulae of both elements were occasionally shown with charges. State symbols were often incorrect and candidates need to take care when choosing state symbols. It was often stated that bromine was a gas at room temperature and that potassium bromide was formed in aqueous solution.

(b)(i) Attempts to explain the term *ionic lattice* required candidates to state that positive and negative ions are arranged in a regular pattern rather than simply using the terms ionic and/or lattice that were given in the question.

(ii) Incorrect use of the term *free* instead of moving / mobile was seen frequently. It is unnecessary to use the word free to answer this question because it contributes nothing to the answer. Free and moving are different things.

(c)(i) Answers to this question were often confused. Candidates are advised to start an answer to similar questions with 'An electrolyte is a **substance...**'

The important things associated with electrolytes are:

- they are aqueous solutions or molten substances containing ions
- they conduct electricity
- they are chemically changed by electricity.

(ii) Potassium, rather than hydrogen, was occasionally given as the product at the cathode. Hydrogen and bromine were occasionally given as products at the wrong electrodes (oppositely charged). Potassium oxide and occasionally potassium bromide were given as the name of the potassium compound formed.

(iii) Even though potassium bromide is a compound containing potassium and bromine only, it was not uncommon to see elements other than potassium and bromine given in answer to this question. Hydrogen was sometimes seen as the answer, particularly by those who gave potassium as the cathode product in (c)(ii).

(d)(i) I and Cl were regularly seen instead of I_2 and Cl_2 . Some equations that used correct formulae were unbalanced. Species with charges were occasionally seen.

(ii) The majority of candidates answered this question very well.

Some candidates unsuccessfully attempted to work out the electron configuration of an iodine atom using the atomic number of 53. This often led to iodine atoms with 17 (or sometimes 3) electrons in the outer shell. Candidates who answered this question successfully realised that because iodine is in Group VII, an iodine atom has seven electrons in its outer shell.

(e) Some correct references to intermolecular forces were seen.

Better performing candidates gave the following response to achieve all three marks:

- When potassium bromide melts, its strong ionic bonds break. When iodine monochloride melts, its weak intermolecular forces break.

The presence of ionic bonds in potassium bromide was often qualified as meaning forces of attraction between atoms or molecules.

References to covalency in iodine monochloride are irrelevant in answering the question as covalent bonds are unaffected when iodine monochloride melts.

Bonds should be described as strong or weak as opposed to high or low or even large or small.

- (f) (i) The most common errors were using Cl instead of Cl_2 and showing electrons on the wrong side.
- (ii) Statements such as 'bromide oxidises' should be avoided. It is not clear whether the meaning is that bromide becomes oxidised itself or bromide oxidises something else. 'They oxidise themselves' is similarly ambiguous. Bromide ion is oxidised is preferable.

Question 5

- (a) The forward reaction is equal to the backward reaction was frequently seen. Very few candidates referred to concentrations of all reactants and products being constant (unchanging) when equilibrium was established. If there was reference to concentration, it was usually to say concentrations become equal rather than constant.
- (b) (i) 'The gas syringe was blocked' was seen quite often. Responses should have stated that there were the same number of moles of gas on both sides of the equilibrium.
- (ii) Candidates found this challenging. Despite being told that 'the position of the equilibrium did not change', many candidates suggested that the mixture turned darker purple because more iodine had been produced. Some candidates attempted an explanation in terms of increase in temperature or in terms of kinetics. Those who said 'the gas was compressed' were merely rewriting the question instead of suggesting why there was a change in colour intensity.
- (c) (i) Candidates should be aware that if temperature increases, equilibrium will shift in the direction of endothermic change. In this case, the equilibrium shifts to the left.
- (ii) It was very common to see answers of both increase and decrease. This is because candidates confuse rate with equilibrium. All chemical reactions (with the exception of enzyme catalysed reactions) occur at increased rates if temperature is increased. Thus, in an equilibrium such as the one referred to in this question both forward and reverse reactions occur at increased rates if the temperature is increased.

Question 6

- (a) Many candidates gave formulae of reactants, even though names were requested. Many candidates started with barium carbonate. Others started with insoluble or otherwise inappropriate reactants. Many candidates omitted to mention that a precipitation reaction requires the mixing of two aqueous solutions. Candidates should be careful with terminology, the filtrate is the liquid which passes through the filter paper in filtration. The term *filtrate* has a different meaning to filter. Washing the residue was often omitted.
- The equation often contained incorrect formulae such as $BaNO_3$ and/or $NaCO_3$. It was not uncommon to see Br as symbol for barium in the equation. Those with correct formulae were often unbalanced.
- (b) (i) O_2 was the product most likely to be identified. NaO and NO_2 were commonly seen as incorrect products. Other incorrect products included NO_3 , Na_2O and Na. The thermal decomposition of the nitrates referred to on the syllabus continues to be an area that is neglected by candidates.
- (ii) Most candidates had $2CuO$ and $4NO_2$ as correct answers but balanced the H_2O with a 3 rather than a 6.
- (iii) There was confusion with colour change of anhydrous cobalt(II) chloride, blue to pink being correct.
- (iv) Those who mentioned that melting point or boiling point should be measured often did not state the values or did not state that the data book value should be used or that melting point or boiling point should be sharp. 'It boils at $100^\circ C$ ' is not the same as stating that the boiling point is $100^\circ C$.

Question 7

- (a) It is essential to show full working out for all calculations. A common error was to divide all three percentages by 13.33. Over approximation often lead to an incorrect final answer, sometimes resulting in $C_5H_{13}O_2$ in this case.
- (b) This was answered very well and candidates successfully calculated the molecular formula. $2(C_2H_4O)$ was occasionally seen.
- (c) (i) Candidates were able to name structural isomers from the definition. Isotope was a common incorrect answer.
- (ii) Candidates found this challenging. Some candidates drew the same compound twice to represent both **T** and **V**.

Some candidates incorrectly thought that when asked to 'show all of the atoms and all of the bonds', the O–H bond did not need to be included; this is not the case and the O–H should be shown.

The rules that carbon atoms have four bonds, oxygen atoms two bonds and hydrogen atoms one bond should always be applied.

- (iii) Those that used correct formulae often had problems with balancing, largely concerning the oxygen atoms. Some were unaware that fractions can be used in balancing equations. It was perfectly acceptable to put a two in front of $C_3H_6O_2$, which meant that fractions did not have to be used.
- (d) (i) Ester was an occasional answer from those candidates who may not have read the question carefully enough. Ethanol was also seen occasionally.
- (ii) The O–H bond was not always included. This was sometimes the only error in the answer.
- (e) (i) The definition for hydrocarbon was well known and candidates clearly stated that it was a substance formed from only carbon and hydrogen atoms.
- (ii) This was answered very well by the majority of candidates.
- (f) Equations that did not contain ethene were occasionally seen and octane did not always appear as the reactant in cracking. Fermentation and hydrolysis were frequent incorrect names for the conversion of ethene to ethanol.

The temperature of hydration was frequently incorrect. The reaction is generally conducted at 300°C but a range was accepted. Temperatures much higher than 350°C were often seen for hydration. Catalysts of iron and nickel appeared occasionally for both processes.

Candidates were expected to give more specific reaction conditions rather than high temperature / high pressure / catalyst.

CHEMISTRY

Paper 0620/43
Theory (Extended)

Key messages

Candidates need to take care when using technical terms, such as *filtrate* or *residue* and ensure they are using them in the correct context.

Electrolysis and the chemistry of esters proved to be weaker areas. These topic areas do contain some demanding content and additional time should be spent covering these areas with students.

General comments

Working should be shown in calculations and this working should be set out so that it can be followed. This will allow method marks to be awarded in calculations even if the final answer is incorrect.

When a question asks for a *chemical equation* a word equation will not be accepted. Where a *word equation* is asked for, candidates should refrain from writing a chemical equation as these are more difficult and increase the likelihood that an error will be made.

Comments on specific questions

Question 1

- (a) The majority of candidates could identify chlorine as the substance used to kill bacteria in drinking water.
- (b) Most candidates gave the correct answer of sulfur dioxide; a number suggested argon or calcium hydroxide or chlorine could be used.
- (c) Almost all candidates correctly identified copper as the electrical conductor used in cables.
- (d) Most answers seen were correct; an appreciable number of candidates suggested substances that were not gases.
- (e) Carbon dioxide and sulfur dioxide were common errors.
- (f) A very common answer was iron, showing some confusion between the contact process and the Haber process.

Question 2

- (a) (i) Despite the question asking for a description in terms of protons, neutrons and electrons, an appreciable number of candidates ignored this and tried to answer the question in terms of only two of the three particles. Candidates need to read questions with care – some candidates ignored the instruction regarding the three subatomic particles and answered in terms of atomic number and mass number.
- (ii) Some candidates missed the fact that the species in the question was an aluminium ion rather than an atom and so stated there were 13 electrons.

- (b)(i) The name of the main ore of aluminium proved was not well known. A common error was to give 'aluminium oxide' or 'alumina' as the ore – these are not correct, they are both Al_2O_3 and are obtained from the ore.
- (ii) An answer comparing the reactivity of aluminium with that of carbon was required. Vague answers such as 'aluminium is reactive' were not sufficient to be awarded the mark.
- (iii) Cryolite is used in the extraction of aluminium oxide since it is a solvent for aluminium oxide. The solution has a far lower melting point than aluminium oxide alone and is a better conductor of electricity. Many candidates claimed that the cryolite changed the boiling (rather than melting) point or that it was the melting point of aluminium that was very high. It should be noted that cryolite is not a catalyst.
- (iv) Some candidates thought that because there was a '+ 4e⁻' that electrons had been gained and so this was reduction. Of those who realised this was electron loss and so oxidation often then went on to say that oxygen had been oxidised; this is incorrect, oxygen is formed in this reaction, the species being oxidised is oxide ions.
- (v) Better performing candidates gave clear explanations of how oxygen formed at the anode reacted with the graphite from which the anode was made to form carbon dioxide. Common weaker answers referred to the carbon coming from the electrolyte or the oxygen from the air.
- (c)(i) The answer needed to include a comparison of the reactivity of zinc and copper. While 'zinc is more reactive than copper' was an acceptable answer, 'zinc is more reactive' was not, since we are not told what zinc is more reactive than; given the wording of the question 'zinc is more reactive' actually means zinc is more reactive than copper(II) sulfate.
- (ii) Most candidates were able to identify this correctly as a redox or displacement reaction.
- (iii) The existence of an inert coating of aluminium oxide on the surface of aluminium was not well known. A common error was for candidates to claim that aluminium was unreactive.

Question 3

- (a) Better performing candidates generally had no difficulty in selecting a property that was common to all metals – such as the ability to conduct electricity.
- (b)(i) Better performing candidates generally had no difficulty in selecting a property that was different for the two metals. A common error was to identify a property common to all metals, which should have been given as the answer to (a).
- (ii) A number of candidates gave the answer to this part in (b)(i).
- (c) Most candidates gave two correct observations. Some candidates repeated the observations given in the question and so did not gain credit, or gave the same observation twice, such as 'fizzes' and 'bubbles' thinking they were two different observations. In this reaction, it is the hydrogen gas that is made that catches fire, not the potassium.
- (d)(i) The test for hydrogen should be known by almost all candidates and while most had some idea about the test there was also some confusion – a burning and not a glowing splint is required in order to ignite the hydrogen.
- (ii) Some candidates did not read the question and stated that increasing the temperature would increase the rate, which, while true, did not gain credit since that information was in the question. The most common correct answer was to increase the concentration. A few candidates stated that the pressure should be increased – this will not work as the substances involved were a solid and an aqueous solution, neither of which are compressible.

- (iii) Better performing candidates included the following key points:
1. Increasing the temperature gives the particles more energy, this results in them moving faster.
 2. As a result of moving faster the particles have more collisions per second. (Note: the reference to time or frequency is essential).
 3. As the particles have more energy, a bigger proportion of particles have energy greater than the activation energy and so a greater percentage of collisions are successful.
- (e) (i) Candidates were expected to realise that the equilibrium would move right and so become (more) pink. However, many candidates did not refer to the equilibrium and just gave a colour. Some candidates confused themselves and having worked out the equilibrium moved right and formed more $(\text{Co}(\text{H}_2\text{O})_6)^{2+}$ they then thought that this would shift the equilibrium left to make the blue species.
- (ii) This was well answered.
- (f) Some excellent answers were seen, although some candidates incorrectly chose to give the charge shown on a species other than Co, such as $\text{Co}(\text{OH})_3^{3+}$.

Question 4

- (a) The characteristics of a homologous series were well known. Common errors were to mix up chemical and physical properties (giving incorrect answers such as 'a trend in chemical properties') and confusion between general and molecular formulae (giving answers such as 'have the same molecular formula').
- (b) Many fully correct answers were seen. The two most common errors were to omit the non-bonding electrons on the oxygen or to omit the bonding pair between the two carbon atoms.
- (c) (i) This was not well answered; equations often had incorrect formulae for ethanol and ethene or additional incorrect products.
- (ii) Very few candidates could recall the equation for fermentation, a number of candidates tried to write an equation for aerobic respiration.
- (iii) Both the greater speed and greater purity of the product were well known advantages. Some candidates mixed up the advantages of each method and stated that catalytic hydration used renewable materials.
- (iv) The most common answer given was based on the renewable nature of the raw materials used. Those who mixed the two methods up often incorrectly stated the product was purer.
- (d) Very few candidates could identify the reagent used to oxidise ethanol.
- (e) (i) Few fully correct structures were seen. Only a minority of candidates could draw an ester group. Structures showing trivalent or pentavalent carbon atoms were common.
- (ii) Better performing candidates could correctly name the ester formed.
- (iii) The name of the homologous series was known by some but polyester was a common incorrect answer.
- (f) (i) This was not well answered. The difference between a strong and weak acid is not based on pH; a very dilute strong acid can have a pH higher than a more concentrated weak acid. Candidates are expected to refer to the fact that weak acids ionise only partially in aqueous solution.

- (ii) Candidates are expected to be familiar with the preparation of soluble salts from acids. There are three steps to the process:
1. Add excess copper carbonate to the acid. Most candidates did not state the copper carbonate should be in excess.
 2. Filter the solution to remove unreacted copper carbonate. The copper ethanoate solution is the filtrate. There was some confusion between the terms 'filtrate' and 'residue'.
 3. The filtrate should be heated to the point of crystallisation and then allowed to cool so that crystals form. It should not be evaporated to dryness.
- (iii) Correct word equations were not common; often carbon dioxide or water were omitted as products. Some candidates decided to attempt a chemical equation rather than a word equation. This made the question much more difficult.

Question 5

- (a) Many fully correct answers to the empirical formula calculation were seen. A common error was to divide the percentages given in the question by the smallest percentage, so missing out the first step of calculating a number of moles of each element. Some candidates mixed up Ni and N, and so divided by the relative atomic mass of nitrogen. A significant number of candidates attempted to guess a formula and made no attempt at showing any working; in these cases, the answer given was invariably incorrect.
- (b)(i) The movement of electrons in the wires was well known.
- (ii) Both anions and cations transfer charge through the solution. It was a common error to specify just one of these two as the answer.
- (iii) Many candidates were able to correctly identify the electrolysis products. Some candidates thought a solution was being electrolysed and so stated hydrogen would be made; this is despite the nickel(II) iodide being identified as molten in both the diagram and the stem to (b). It was expected that candidates would write the equation for the formation of nickel (since ionic half-equations for the cathode reactions are on the syllabus) but many attempted the equation for anodic reaction and were often successful.
- (c)(i) While many candidates were able to correctly state that copper was deposited on the negative electrodes, a number of candidates simply stated that copper ions go the negative electrode without any mention of copper being formed and coating the electrode.
- (ii) This was often correct with hydrogen as the most common incorrect gas formed.
- (iii) The fact that copper atoms lose electrons and form copper ions which pass into the solution was not well known. Some answers put the mass loss down to just the loss of electrons.
- (iv) Some fully correct answers were seen with clear explanations of the colour changes seen in both sets of apparatus. Other candidates clearly did not understand the difference in electrolysis products when using an inert cathode compared to using a reactive cathode.

Question 6

- (a)(i) This part involved two stages; the calculation of the relative formula mass of calcium hydroxide and using this value to calculate the number of moles of calcium hydroxide. There were some common errors in the calculation of the relative formula mass – having just one hydroxide ion being the most common. Where candidates set their work out so that it could be followed, the error could be carried forward and credit given for the correct use of the incorrect relative formula mass. Consequential marks can only be awarded if candidates set out their working in a clear and logical manner.
- (ii) A common error was to use the value as 24 dm^3 rather than $24\,000 \text{ cm}^3$. Candidates needed to consider the units used for volume in the question.

- (iii) Better performing candidates were able to use the 6:1 ratio in the equation to obtain a correct value. A common error was to not use the limiting reagent identified from the values in (a)(i) and (a)(ii).
 - (iv) This two-step calculation firstly required the relative formula mass to be determined and then using that figure to work out the mass of the number of moles stated in (a)(iii). An error in the calculation of the relative formula mass could be carried forward, but only if the working was presented in a clear and logical manner by the candidate.
 - (v) The percentage yield calculation was often correct.
- (b)(i) Most candidates were able to state that heating was required to bring about thermal decomposition.
- (ii) This question part was generally very well answered. Many candidates identified oxygen as the colourless gas and were able to construct a fully correct equation.
- (c)(i) The colour of methyl orange in an acid was well known.
- (ii) There were many errors in the definition of an acid; many candidates incorrectly stated it was a proton receiver.
 - (iii) Candidates found this part challenging and few were able to complete the equation to show the transfer of a proton from HClO_3 (the acid) to H_2O (the base).

CHEMISTRY

Paper 0620/51
Practical Test

Key messages

In the planning question (**Question 3**) there is no need to write a list of apparatus at the start of the answer, any apparatus used should be referred to in the description of the experiment so that it is clear for what purpose that apparatus has been used.

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

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

Candidates should avoid giving lists of answers, as an incorrect response can contradict a correct one. For example, if the correct answer is 'precipitate dissolves' and a candidate writes 'precipitate dissolves and a white solid forms', no mark can be awarded.

General comments

The vast majority of candidates successfully attempted all of the questions. Almost all centres were able to gain the expected results in **Question 1**, with *Experiment 5* showing a large increase in time compared to *Experiments 1–4*.

Candidates found the last question, **Question 3**, challenging.

Comments on specific questions

Question 1

- (a) The table of results was often completed correctly. A common error was completing the time for *Experiment 5*, leaving the time in minutes and seconds.
- (b) Most candidates plotted the points correctly but often not clearly. Poorly drawn line graphs were evident, without a smooth curve. The section between 10 cm³ and 30 cm³ proved challenging with some candidates drawing a straight line with a ruler. Others drew a best-fit straight line through all of the points.
- (c) The formation of a yellow precipitate was the expected description of the appearance of the mixture in the flask. Vague references to milky and white were ignored.
- (d) (i) Candidates should be encouraged to show clear construction lines and ensure that these lines are parallel to the axes. A significant number of candidates did not show clearly on the grid how they worked out their answer.
- (ii) The question asked for a calculation and marks were lost for leaving the answer as a fraction. Incorrectly rounded numbers could not be awarded credit.
- (e) (i) A few candidates confused rate and time and so incorrectly stated *Experiment 5*, as it had the longest time.

- (ii) Good responses referred to the presence of more particles and hence more frequent collisions between the particles. A lack of understanding was seen with many candidates suggesting that at higher concentration the particles had more energy or that more collisions released more energy.
- (f) Many candidates gave a burette or pipette. Some candidates did not read the question and stated that a measuring cylinder is more accurate than a measuring cylinder.
- (g) The difference to the results caused by using a smaller conical flask was only realised by better performing candidates. Many candidates thought the concentration or pressure of the reactants would increase and the rate of reaction would increase. Candidates who have done this sort of experiment should be familiar with how changing the reaction vessel will change the results obtained. In this case, a greater depth of reacting mixture would lead to the cross disappearing from view in shorter times.
- (h) A common mistake was to join their sketch line to their plotted line so having decided the reaction would be slower they then showed the reaction slower most of the time but having the same rate at the highest or lowest concentration. A significant number of candidates did not follow the instruction to draw their sketch on the grid and filled the space at (h) with a sketch of a graph which was not comparable with the original on the previous page.

Question 2

Solution **A** was dilute nitric acid.

Solid **B** was zinc carbonate.

- (a) A number of candidates recorded unexpected pH numbers greater than 7.
- (b) This was generally well answered with candidates observing bubbles or effervescence.
- (c) Only a minority recorded that a blue solution was formed, The formation of a black colouration/precipitate showed a lack of understanding, having just added copper(II) oxide to the solution. The mention of green solutions and blue precipitates being formed scored no credit.
- (d) Marks were awarded for noticing that the solid turned yellow on heating. A significant number of candidates did not describe that the solid returned to a white colour after standing for a minute. Credit was given for recording the formation of water droplets/condensation.
- (e) Candidates were required to realise that the gas produced was carbon dioxide and then give the test for carbon dioxide. Blue litmus is not an appropriate test since candidates should know that there are other acidic gases. Similarly, the use of a lighted splint is not appropriate. The fact that the splint goes out tells us that the gas does not support combustion and is not flammable – the same result is obtained with nitrogen and ammonia.
- (f) (i) The expected observation was that a white precipitate formed.
(ii) The precipitate dissolving was missed by many candidates.
- (g) (i) The expected observation was that a white precipitate formed.
(ii) The precipitate dissolving was missed by many candidates.
- (h) The majority of candidates tested the gas with litmus paper, which turned blue. Many did not record the bubbles in the mixture. Credit was awarded for reference to a pungent smell but identifying ammonia was ignored as the name of a gas is not an observation.
- (i) Only the better performing candidates realised that a positive nitrate test showed the solution was nitric acid. Some candidates realised that **A** was an acid.
- (j) Candidates found identifying solid **B** challenging. Calcium and ammonium compounds were frequently named. Despite the correct observations to the tests some candidates did not use the notes given on pages 11 and 12 to help identify the solid **B**.

Question 3

A significant number of candidates did not attempt the question.

There were a number of acceptable methods for determining the solubility of a salt in water. Many candidates scored credit for specifying a measured volume of water and heating it to 40°C. The commonest method was to add potassium chloride to the water until no more dissolved, filtering off the excess salt, drying the solid and weighing the residue. This mass was then subtracted from the initial mass taken. Many candidates using this method did not mention 'add the potassium chloride to the water until no more dissolves/until in excess' and could not be awarded that mark.

Variants involved heating the filtrate to dryness or weighing the beaker of water initially and then reweighing when the solution was saturated.

Credit was given for naming the apparatus used to measure the volume of water and indicating that the mixture of the potassium chloride and water should be stirred to facilitate the dissolving.

A common error was to produce a plan based on the time it took the salt to dissolve or the speed of the process rather than the mass that would dissolve. Candidates should read the question carefully as this clearly related the solubility of the salt to the mass of the salt.

CHEMISTRY

Paper 0620/52
Practical Test

Key messages

- If, when two solutions are added to together, the product is cloudy this will be because a precipitate has formed. The solid formed should be called a *precipitate*.
- When reporting the result of a qualitative test, if there has been no change then candidates should say this, or state that the solution remains colourless; saying the solution becomes colourless is saying that a change took place and so is incorrect.
- In the planning question (**Question 3**) there is no need to write a list of apparatus at the start of the answer, any apparatus used should be referred to in the description of the experiment so that it is clear for what purpose that apparatus has been used.

General comments

Almost all Centres were able to gain the expected results in **Question 1**, with *Experiment 1* showing a decrease in temperature and *Experiment 2* an increase.

If glassware is washed in a dishwasher then it would be wise to rinse items such as test-tubes (which do not always get rinsed very well in a dishwasher) with water; the substance used as a cleaner in dishwashers is often strongly alkaline and can leave a residue in test-tubes.

Candidates should complete graph work in pencil so that errors can be erased.

Solutions should be made up using distilled or deionised water to avoid false positive tests for ions such as chloride.

Comments on specific questions

Question 1

- (a) The vast majority of candidates obtained three sets of results with an increasing magnitude of temperature change as the mass of solid **C** increased. Almost all candidates correctly included the sign of the temperature change in their table. Most candidates gained results that were comparable to the Supervisor's result.
- (b) The vast majority of candidates gained the expected results. A small percentage of candidates did not record all temperatures and temperature changes to the same degree of accuracy, i.e. a consistent number of decimal places, and so did not gain full credit.
- (c) Few errors in plotting were noted, although the most common error was to plot the points for 6 g of solid **C** or solid **D** at 5 g on the x-axis. A minority of candidates did not read the instruction regarding drawing two straight lines but a much larger number did not have their lines meeting at (0,0). If no solid has been added, then there cannot be a temperature change and so both lines had to pass through the pre-plotted point at (0,0). Some candidates plotted points or drew graph lines in ink – this means that if an error is made the point/line that is wrong cannot be erased.
- (d) Most candidates successfully extrapolated their graph line to 8 g, but there were then some errors in reading from the scale.

- (e) A number of candidates suggested the reaction was endothermic. It is suspected that some of these candidates had not read the question carefully and so had not noticed this question part was about solid **D** while the previous question part had been about solid **C**.
- (f) Most candidates realised the reaction would be over after two hours, but not all of these suggested the solution would return to room temperature. Incorrect answers included that the solution would remain at its highest temperature indefinitely or that the temperature would continue to increase at the same rate – so giving temperature changes 120 times the ones reported in the experiments.
- (g) The majority of candidates realised that if the quantity of water was increased, the temperature change would be smaller; many did not give the expected quantitative answer – namely that with twice the volume of water the temperature changes would be halved. A few candidates considered water as the limiting reactant and so incorrectly stated the temperature change would double.
- (h) This question asked for a change to the experiment. Repeating the experiment is not a change to the experiment, it is simply doing the same experiment again. Of those who did suggest a suitable change the split between adding extra insulation or a lid as opposed to changing the way in which the water is measured was approximately equal. Some candidates forgot about the practical they had just completed and suggested using a polystyrene cup – despite the fact they had just used one.
- (i) The reliability of an experiment can be checked by repeating it and comparing results. Unfortunately, some candidates suggested repeating it with different volumes of water; this would produce different results and would not allow you to check comparability.

Question 2

- (a) Solid **E** was hydrated iron(II) sulfate. This is a pale green solid. Old samples may have had some brown tint to the solid due to oxidation to iron(III). However, a number of candidates reported that the solid was blue-green.
- (b) Most candidates correctly noted the colour change to yellow or brown, but relatively few noticed the steam being given off or the condensation forming at the top of the test-tube.
- (c) As iron(II) sulfate does not contain a halide ion, there should not have been a precipitate formed. A precipitate is only obtained with sulfates if the concentrations used are much too high. A wide variety of observations were reported, ranging from 'no change' to 'black precipitate'.
- (d) Most candidates correctly reported the formation of a white precipitate. It should be noted that the term *precipitate* is required.
- (e) Iron(II) salt solutions normally give a deep green precipitate under laboratory conditions, these will then slowly become brown as the iron(II) is oxidised to iron(III). Despite this, some candidates reported a blue precipitate (signifying copper(II) ions) or a grey-green precipitate (the colour obtained for chromium(III) with aqueous ammonia but not sodium hydroxide), some candidates reported that the precipitate re-dissolved – this does not happen with iron(II) ions.
- (f) Solid **E** was often identified correctly, although it was a common error to omit the oxidation state of iron despite the fact that the *Notes for use in qualitative analysis* makes it clear that the test results for iron(II) and iron(III) are not the same. Candidates are advised to write the name rather than the formula when giving identities of compounds.
- (g) Solid **F** was calcium chloride. Solutions of calcium chloride should show a weakly acidic pH (around pH 6). However, a wide range of pH values were reported, ranging from strongly acidic to strongly alkaline. One possible explanation is that the glassware/stopper used was not clean. Glassware should be rinsed before use.

- (h)(i) Most candidates correctly reported the formation of a white precipitate. However, some candidates also reported additional impossible observations such as 'fizzing'. It should be noted that a solution cannot be 'white'; solutions are clear. If a solution looks white in these qualitative ion tests, it will be due to the formation of a white precipitate.
- (ii) Most candidates correctly reported that the precipitate did not dissolve.
- (i) Most candidates report that no change occurred. However, some candidates stated that the solution became colourless – suggesting that it was not colourless before, which is incorrect.
- (j) Most candidates identified the calcium ion as being present.

Question 3

Candidates who opted to carry out a titration generally performed well on this question. The most common errors encountered in this method were:

1. Using Universal Indicator, which is not suitable for using in a titration as it shows a series of gradual colour changes rather than having a sharp end point.
2. Not adding the reagent in the burette slowly or dropwise to the other reagent. Rapid addition will lead to the end point being overshot.

Candidates would be well advised to plan their answers out before starting to write, this would avoid the need to try and insert missing parts at a later stage. There is no need to write a list of apparatus at the start, if a mark is available for selecting suitable apparatus then it must be clear what that apparatus is being used for and so it must be mentioned in the method.

CHEMISTRY

Paper 0620/53
Practical Test

Key messages

- If, when two solutions are added together, the product is cloudy this will be because a solid has formed. The solid formed should be called a *precipitate*.
- In the planning question (**Question 3**) there is no need to write a list of apparatus at the start of the answer. Any apparatus used should be referred to in the description of the experiment so that it is clear for what purpose that apparatus has been used.
- Candidates should be familiar with the technique of a flame test. A flame test involves placing a small amount of an ionic solid (normally on a wire) into a roaring Bunsen flame. The colour of the Bunsen flame then changes. Flame tests do not involve using a lighted splint and the result cannot be 'squeaky pop' or 'flame goes out'.

General comments

Almost all centres were able to gain the expected results in **Question 1**, with *Experiment 1* and *Experiment 2* showing an increase in temperature followed by a decrease.

Candidates should complete graph work in pencil so that errors can be erased.

Comments on specific questions

Question 1

- (a) Almost all candidates were able to obtain the expected results showing an increase in temperature followed by a decrease.
- (b) A number of errors in plotting were noted. Most candidates followed the instruction to draw two intersecting straight lines. Some candidates did 'dot to dot' lines or curves. Some candidates are plotted points or drew graph lines in ink – this means that if an error is made the point/line that is wrong cannot be erased.
- (c) Almost all candidates were able to obtain the expected results showing an increase in temperature followed by a decrease.
- (d) A number of errors in plotting were found and some candidates ignored the instruction to draw two intersecting straight lines.
- (e) (i) A number of candidates misread their graph scales despite having just successfully plotted the graph. A small number of answers stated the temperature rather than the volume.
- (ii) Most candidates worked out that a smaller volume would be required; they did not go on to give a quantitative answer and reason.
- (f) Candidates need to ensure that when writing *exothermic* that the 'x' does not look like an 'n' as the intended answer must be unambiguous.

- (g) (i) Almost all candidates realised that the burette needed to be cleaned, with most candidates focussing on the acid left from the previous experiment.
- (ii) Many candidates focused on removing the acid from the previous experiment despite having already removed it with water. Only the better performing candidates realised the water would dilute the acid used in the second experiment and so had to be removed.
- (h) Many candidates did not realise that a source of error is not removed by repeating an experiment – if the same method and apparatus is used then that source of error is still there. Better responses identified heat loss or using a measuring cylinder as a source of error.

Question 2

- (a) (i) A number of candidates confused flame test with testing a gas with a lighted splint. The result of a flame test should be a colour, not 'the flame went out'.
- (ii) Most candidates gave an acceptable pH value.
- (b) By this stage candidates could have identified solution **T** as aqueous sodium hydroxide. The results given by some candidates suggested that having worked out this was the reaction between an aqueous zinc salt and aqueous sodium hydroxide all that they needed to do was give observations similar to those in the *Notes for use in qualitative analysis*. However, in this instance the tests were reversed, with the zinc salt being added to the sodium hydroxide. Almost all candidates missed the initial formation of a white precipitate, which then quickly dissolves before any more of the zinc salt is added.
- (c) The gas given off should have been ammonia. Some candidates reported positive tests for chlorine, presumably thinking that because ammonium chloride was used that chlorine would be made, it is not possible for chlorine to be made in this way. The expected test and result was that for ammonia.
- (d) Many candidates missed the initial green precipitate, which rapidly dissolves giving a green solution. The final green precipitate that should have been formed when excess was added was often reported as being a green solution.
- (e) Most candidates could correctly identify solution **T**.
- (f) Most candidates stated that liquid **U** was colourless. It should be noted that 'clear' is not accepted as an alternative to colourless; coloured solutions, such as aqueous copper(II) sulfate, are coloured and clear.
- (g) Many candidates noted the formation of a yellow precipitate.
- (h) Most candidates reported that liquid **U** caught fire, some incorrectly stated that it extinguished the lighted splint.
- (i) A common error was to state that liquid **U** contained iodide ions; this was presumably because of the yellow precipitate seen in **Question 2(g)**, despite the fact that silver nitrate had not been used.

Question 3

This question required candidates to extract the mixture of pigments from the leaves and then to analyse the pigments. Unfortunately, most answers seen concentrated on either extracting the pigment from the leaves or on conducting chromatography rather than addressing both aspects; relatively few answers described how to obtain the pigment from the leaves and then conduct chromatography. It was not uncommon for candidates who missed out the pigment extraction stage to place the leaf directly on chromatography paper. Some candidates were not sure what to do with the sand and so used it as a filtration medium or even the stationary phase in chromatography.

CHEMISTRY

Paper 0620/61
Alternative to Practical

Key messages

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

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

Candidates should avoid giving lists of answers, as an incorrect response can contradict a correct one. For example, if the correct answer is 'precipitate dissolves' and a candidate writes 'precipitate dissolves and a white solid forms', no mark can be awarded.

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

General comments

The vast majority of candidates successfully attempted all of the questions. Candidates found the last question, **Question 4**, challenging.

The majority of candidates were able to complete tables of results from readings on diagrams, as in **Question 2**.

Comments on specific questions

Question 1

- (a) Some candidates had difficulty identifying the burette. Pipette, funnel and measuring tube were common incorrect answers.
- (b) Methyl orange, phenolphthalein and litmus gained credit. Universal Indicator is not suitable for use in titrations.
- (c) (i) This was generally well-answered with most candidates identifying the anomalous point.
(ii) Many answers were vague referring to human error, misreading the burette or parallax errors. Credit was awarded for difficulties in judging the end point and consequent overshooting. Using too much sodium hydroxide was a high-level response.
(iii) Some candidates were able to calculate the average volume of nitric acid and give their answer to an appropriate number of decimal places.
- (d) Marks were awarded for realising that less acid was used and therefore the acid was more concentrated. Confused answers were common. Descriptions of a displacement reaction showed a lack of knowledge and understanding. Some candidates stated that the nitric acid must be less concentrated as it was called 'dilute nitric acid'.

Question 2

- (a) The table of results was often completed correctly. A common error was completing the volume for *Experiment 1*, suggesting candidates may not have read through the experiment details carefully. Errors were also seen recording the times for *Experiments 4* and *5* leaving the time in minutes and seconds or just recording the seconds and ignoring the minutes.
- (b) Most candidates plotted the points correctly but often not clearly. Poorly drawn line graphs were evident, without a smooth curve. The section between 10cm^3 and 30cm^3 proved challenging, with some candidates drawing a straight line with a ruler. Others drew a curve with a point of inflection and so had the curve becoming less steep to the left rather than steeper.
- (c) (i) Candidates should be encouraged to show clear construction lines on the graph and ensure that these lines are parallel to the axes. A significant number of candidates did not show clearly on the grid how they worked out their answer.
- (ii) The question asked for a calculation and marks were lost for leaving the answer as a fraction. Incorrectly rounded numbers could not be awarded credit.
- (d) (i) A few candidates confused rate and time and so incorrectly stated *Experiment 5* as it had the longest time.
- (ii) Good responses referred to the presence of more particles and hence more frequent collisions between the particles. A lack of understanding was seen with many candidates suggesting that at higher concentration the particles had more energy or that more collisions released more energy.
- (e) Many candidates gave a burette or pipette. Some candidates did not read the question and stated that a measuring cylinder is more accurate than a measuring cylinder.
- (f) The difference to the results caused by using a smaller conical flask was only realised by better performing candidates. Many candidates thought the concentration or pressure of the reactants would increase and the rate of reaction would increase. Candidates who have done this sort of experiment should be familiar with how changing the reaction vessel will change the results obtained. In this case a greater depth of reacting mixture would lead to the cross disappearing from view in shorter times.
- (g) A common mistake was to join their sketch line to their plotted line so having decided the reaction would be slower they then showed the reaction slower most of the time but having the same rate at the highest or lowest concentration.

Question 3

- (a) The majority correctly identified hydrogen as the gas given off in **test 2**. Responses indicated that some candidates found this challenging.
- (b) Solution **A** was often identified as an acid but many did not use the result of **test 3** to identify sulfate ions.
- (c) Candidates were required to realise that the gas produced was carbon dioxide and then give the test for carbon dioxide. Blue litmus is not an appropriate test since candidates should know that there are other acidic gases. Similarly the use of a lighted splint is not appropriate. The fact that the splint goes out tells us that the gas does not support combustion and is not flammable – the same result is obtained with nitrogen and ammonia.
- (d) (i) The expected observation was white precipitate formed. Many responses mixed up this test with the nitrate ion test and produced ammonia despite no aluminium being added and the mixture not being heated.
- (ii) The precipitate dissolving was known by most candidates.
- (e) (i) The expected observation was that a white precipitate formed.
- (ii) The precipitate dissolving was known by most candidates.

Question 4

There were a number of acceptable methods of determining the solubility of a salt in water. Many candidates scored credit for specifying a measured volume of water and heating it to 40°C. The commonest method was to add potassium chloride to the water until no more dissolved, filtering off the excess salt, drying the solid and weighing the residue. This mass was then subtracted from the initial mass taken.

Variants involved heating the filtrate to dryness or weighing the beaker of water initially and then reweighing when the solution was saturated.

Credit was given for naming the apparatus used to measure the volume of water and indicating that the mixture of the potassium chloride and water should be stirred to facilitate the dissolving.

A common error was to produce a plan based on the time it took the salt to dissolve or the speed of the process rather than the mass that would dissolve. Candidates should read the question carefully as this clearly related the solubility of the salt to the mass of the salt.

CHEMISTRY

Paper 0620/62
Alternative to Practical

Key messages

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

When a question asks for the name of a chemical, a correct formula is acceptable. However, if a candidate answers with an incorrect formula, then the mark cannot be awarded.

General comments

This session, **Question 4** was a planning task based on the determination of the concentration of an alkaline solution. The most common method was by titration, although other methods could gain credit

The vast majority of candidates were able to complete tables of results from readings on diagrams in **Question 2**.

Comments on specific questions

Question 1

- (a) Most candidates correctly labelled the (gas) syringe.
- (b) The label on the *y*-axis proved challenging. Candidates had to say 'volume' or give the units as cm^3 , whilst referring to the gas or carbon dioxide.
- Most realised that the graph was horizontal because the reaction had finished, but fewer mentioned that calcium carbonate was the limiting factor.
- (c) The graph for lumps of calcium carbonate was well drawn by the majority of candidates. However, a significant number of candidates left this question blank.
- (d) The test for carbon dioxide was well known.

Question 2

- (a) Most candidates could read the thermometers correctly, although a minority omitted the minus sign.
- (b) Most candidates could read the scales correctly.
- (c) The points were usually plotted correctly and the lines were generally well drawn; many did not go through the origin. Many candidates did not label the lines.
- (d) Most candidates successfully extrapolated their graph line to 8 g; some errors in reading from the scale were seen.

- (e) A number of candidates suggested the reaction was endothermic. It is suspected that some of these candidates had not read the question carefully and so had not noticed this question part was about solid **D** while the previous question part had been about solid **C**.
- (f) Most candidates realised the reaction would be over after two hours, but not all of these suggested the solution would return to room temperature. Incorrect answers included that the solution would remain at its highest temperature indefinitely or that the temperature would continue to increase at the same rate – so giving temperature changes 120 times the ones reported in the experiments.
- (g) The majority of candidates realised that if the quantity of water was increased, the temperature change would be smaller; many did not give the expected quantitative answer – namely, that with twice the volume of water the temperature changes would be halved. A few candidates considered water as the limiting reactant and so incorrectly stated that the temperature change would double.
- (h) This question asked for a change to the experiment. Repeating the experiment is not a change to the experiment, it is simply doing the same experiment again. Of those who did suggest a suitable change the split between adding extra insulation or a lid as opposed to changing the way in which the water is measured was approximately equal.
- (i) The reliability of an experiment can be checked by repeating it and comparing results. Unfortunately, some candidates suggested repeating it with different volumes of water; this would produce different results and would not allow you to check comparability.

Question 3

- (a) Some candidates realised that iron(II) sulfate is green. Despite the fact that the question referred to the solid, a significant minority incorrectly called it a solution.
- (b) The qualitative analysis tests were generally well known. Most candidates realised that there would be no change or no precipitate with silver nitrate solution.
- (c) 'White precipitate' was by far the most common answer.
- (d) Most answers referred to the green precipitate.
- (e) Green precipitate was the most common answer.
- (f) Most candidates correctly identified calcium as the cation; a few could not be awarded the mark as they wrote Ca^+ .

Question 4

Candidates who opted to carry out a titration normally scored highly on this question. The most common errors encountered in this method were:

- 1 Using Universal Indicator, which is not suitable for using in a titration as it shows a series of gradual colour changes rather than having a sharp end point.
- 2 Not adding the reagent in the burette slowly or dropwise to the other reagent. Rapid addition will lead to the end point being overshoot.

Candidates would be well advised to plan their answers out before starting to write, this would avoid the need to try and insert missing parts at a later stage. There is no need to write a list of apparatus at the start, if a mark is available for selecting suitable apparatus then it must be clear what that apparatus is being used for and so it must be mentioned in the method.

CHEMISTRY

Paper 0620/63
Alternative to Practical

Key messages

If, when two solutions are added together, the product is a solid, the solid formed should be called a *precipitate*.

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

Plotted points on a grid should be clearly visible, e.g. crosses. Straight line graphs should be drawn with a ruler.

General comments

Candidates found **Questions 3 and 4** to be the most demanding.

The majority of candidates were able to complete the tables of results from readings on diagrams and plot points successfully on a grid as in **Question 2**.

Comments on specific questions

Question 1

- (a) (i) Common incorrect answers were scales or weighing machine.
- (ii) Only a minority of candidates identified the crucible. This suggests that most candidates have not heated solids strongly over a Bunsen burner. Beaker and flask were common responses.
- (b) Many candidates did not know what the 'air hole' was. Contradictory answers such as closed and blue flame were common. This suggests that many candidates had not used a Bunsen burner on a regular basis.
- (c) Very few candidates understood the idea of heating the solid to constant mass. Common incorrect answers heated the crystals and looked for steam or tested with anhydrous copper sulfate.
- (d) Lots of physical tests were seen. Candidates who understood what a chemical test was scored credit; some got the colour changes reversed or mixed up copper sulfate and cobalt chloride.

Question 2

- (a) Almost all candidates were able to complete the temperatures from the thermometer diagrams.
- (b) A number of errors in plotting were noted. Most candidates followed the instruction to draw two intersecting straight lines. The vast majority used a ruler to draw the straight lines.
- (c) Almost all candidates were able to complete the temperatures from the thermometer diagrams.

- (d) A number of errors in plotting were found and some candidates ignored the instruction to draw two intersecting straight lines. Some drew a straight line from point 1 to point 4 instead of point 3, so the lines crossed at 15 cm^3 .
- (e) (i) A number of candidates misread their graph scales despite having just successfully plotted the graph. A small number of answers stated the temperature rather than the volume. Many did not show any working on the grid.
- (ii) Most candidates worked out that a smaller volume would be required; others did not give a quantitative answer and explanation.
- (f) Candidates need to ensure that when writing *exothermic* that the 'x' does not look like an 'n' as the intended answer must be unambiguous.
- (g) (i) Almost all candidates realised that the burette needed to be cleaned, with most candidates focussing on the acid left from the previous experiment.
- (ii) Many candidates still focussed on removing the acid from the previous experiment despite having already removed it with water. Only the better performing candidates realised the water would dilute the acid used in the second experiment and so had to be removed.
- (h) Many candidates did not realise that a source of error is not removed by repeating an experiment – if the same method and apparatus is used then that source of error is still there. Better responses identified heat loss or using a measuring cylinder as a source of error.

Question 3

- (a) (i) There was a number of candidates that confused a flame test with testing a gas with a lighted splint. The result of a flame test should be a colour, not 'the flame went out'. Many candidates showed confusion and gave answers based on bubbling, precipitates or squeaky pops.
- (ii) Many candidates thought that sodium hydroxide was either an acid or a weak alkali. A minority realised that it was strongly alkaline and so gave a pH from 11–14.
- (b) Most candidates gave the observations you would expect for adding sodium hydroxide to an aqueous solution of a zinc salt, hence thinking that the sodium hydroxide was in excess in the second step rather than the first. Therefore, the correct response was a white precipitate that is soluble and then reappears.
- (c) The expected test and result was that for ammonia and was that red litmus turns blue. Blue litmus is not a suitable test for ammonia. Some performed tests with lighted splints or thought that chlorine would be produced and would bleach litmus.
- (d) Many candidates missed the final green precipitate that should have been formed when excess chromium(III) chloride solution was added. This was often reported as being soluble, forming a green solution.
- (e) Many candidates could correctly conclude that solution T was a fuel, an alcohol or an organic substance. A common answer was to say it was a copper compound due to the blue flame in the second test, not understanding that touching something with a lighted splint is not a flame test.

Question 4

This investigation has two stages; extraction of the pigment and then separation by chromatography. The question required candidates to describe the extraction of the pigments from the leaves and then to analyse the pigments. Unfortunately, most answers concentrated on either extracting the pigment or on conducting chromatography rather than addressing both aspects. Relatively few answers described how to obtain the pigment from the leaves and then conduct chromatography. Good answers gave descriptions of the formation of coloured spots up the paper and the calculation of R_f values. It was not uncommon for candidates who missed out the pigment extraction stage to place the leaf directly on chromatography paper.