CHEMISTRY

Paper 0620/11
Multiple Choice (Core)

Question Number	Key
1	C
2	B
3	B
4	D
5	C
6	A
7	B
8	C
9	B
10	A

Question Number	Key
11	D
12	B
13	C
14	B
15	C
16	A
17	C
18	A
19	A
20	B

Question Number	Key
21	A
22	D
23	A
24	D
25	D
26	D
27	B
28	D
29	D
30	A

Question Number	Key
31	A
32	D
33	B
34	C
35	C
36	C
37	C
38	D
39	B
40	B

General comments

The number of candidates who sat this paper was relatively low. Candidates found the paper challenging with few gaining high marks.

Overall candidates found **Questions 7**, **10**, **15**, **24**, **26**, **31**, **36** and **38** to be the most challenging with questions on structure and bonding and organic chemistry being the least well answered. **Questions 1**, **8**, **13**, **21** and **28** were found to be the least challenging.

Comments on specific questions

Question 6

Options **B** and **C** were commonly chosen, suggesting some confusion about the conductivity of ionic substances in different physical states.

Question 7

Most candidates had only partial knowledge of the structure and the uses of graphite, with options **A** and **D** often chosen as the correct answer.

Question 10

Option **D** was the most popular answer, which suggests that candidates identified a positive–negative attraction even if they did not identify the correct product. Candidates should take care to check the physical state of a substance during electrolysis. They should also consider whether the product they suggest would react with the water in an aqueous solution.

Question 15

Questions on the colour changes of copper(II) sulfate and cobalt(II) chloride are often poorly recalled. This question was no different with the distribution of options suggesting some degree of guessing occurred.

Question 17

Option **D** was the most common answer for many candidates.

Question 23

This question highlighted a confusion between groups and periods in the Periodic Table. Candidates mostly chose option **B**.

Question 24

Options **C** and **B** were common incorrect answers. The general reactivity of metals and their extraction from metal oxides should be well known by candidates.

Question 26

Options **B** and **C** were the most common answers. This suggests that candidates recalled some of the reactions in the extraction of iron but confused the basic nature of calcium oxide or misapplied it to steel formation.

Question 30

This was a challenging question. Option **B** was the most common answer, suggesting that candidates were confusing acids and alkalis in the liberation of ammonia from an ammonium salt.

Question 31

The production of carbon dioxide in the combustion of methane was well recalled. The decomposition of carbonates or their reaction with acids was not. Candidates who performed well overall most commonly chose option **D,** whereas others tended to choose option **C.**

Question 33

Option **C** was a common incorrect answer.

Question 35

The uses of petroleum fractions were not well recalled. Option **A** was chosen by some candidates. Candidates who performed less well overall were also likely to choose option **D**.

Question 38

All the options were chosen ahead of the correct answer in this question with option **A** being the most popular answer. Candidates should recall that cracking requires high temperatures. Oxygen must therefore be removed to avoid the risk of combustion. With no oxygen, no carbon dioxide can be formed.

CHEMISTRY

Paper 0620/12
Multiple Choice (Core)

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

General comments

Candidates found questions on organic chemistry difficult both for recall and for application questions. Questions on particles, separation techniques, atomic structure and bonding were well answered. Candidates found **Questions 1**, **3**, **7** and **8** to have the lowest demand. **Questions 21**, **25**, **34**, **37**, **39** and **40** were found to be the most challenging.

Comments on specific questions

Question 11

Option **C** was the most common incorrect answer, suggesting some confusion between endothermic and exothermic processes. There was also evidence of guessing by some candidates.

Question 14

Option **D** was chosen by the majority of candidates, which suggests they were not choosing the fastest rate based on the shape of the curve, but perhaps just choosing the largest volume. A few candidates also chose option **A**.

Question 21

Whilst the correct answer was the most popular option for candidates who performed well overall, it was the least popular option for others. Option **B** was the most common incorrect answer.

Question 23

This question discriminated well between candidates. Some candidates appeared to be guessing.

Question 25

Option **B** was chosen by most of the candidates, which suggests that most recalled the inert nature of silver in the presence of water or steam. A few candidates chose option **D**.

Question 29

Option **B** was strongly favoured by candidates who performed less well overall. Some candidates chose options **A** or **C**.

Question 34

Many of the questions on organic chemistry were not well answered. This question on basic terminology was correctly answered by a minority of the candidates. Option **A** was chosen by most of the candidates. Candidates should recall that hydrocarbons contain hydrogen and carbon only.

Question 35

A minority of candidates were able to recall the uses of the named petroleum fractions. Although option **A** was slightly favoured, many candidates appeared to be guessing.

Question 37

This question was not well answered, with only a minority selecting the correct answer. Candidates should be able to recall the bonding within the named compounds in the syllabus. Option **C** was the most commonly chosen answer, suggesting that, whilst candidates recalled the pairing of electrons in bonds, they did not always remember to include the electrons in the C–C bond.

Question 39

Option **C** was the most commonly chosen incorrect answer. Partial recall of bonding in unsaturated molecules is shown in this answer but candidates should note that a hydrogen atom forms only one covalent bond, making double bonds involving hydrogen impossible.

Question 40

A minority of the candidates answered this question correctly. Option **B** was the most common answer. Although this option agrees with the first statement in the question, candidates should make sure that they consider all the information given before selecting their answer.

CHEMISTRY

Paper 0620/13
Multiple Choice (Core)

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

General comments

The number of candidates who sat this paper was relatively low. Candidates found the paper slightly more demanding than in previous years with relatively few gaining the highest marks.
Candidates found **Questions 1**, **8** and **13** having the lowest demand and **Questions 4**, **19**, **21**, **26** and **39** having the highest demand.

Comments on specific questions

Question 4

This was a demanding question with almost half of the candidates choosing option **D**. This suggests that many candidates confused the meaning of the positive sign on the sodium ion and added an extra electron to the electronic structure of a sodium atom.

Question 5

Although a small majority of candidates answered this correctly, many chose option **A.** This suggests confusion between the term ‘compound’ and ‘mixture’. Nearly all candidates recalled the need for a metal to be present within an alloy.

Question 11

Although most of the candidates who performed well overall chose the correct answer, some confused the terms endothermic and exothermic and selected option **C**. Some candidates appeared to be guessing.

Question 15

This question discriminated well between candidates. The standard test for water using anhydrous salts is often poorly recalled by candidates who perform less well overall. This group were more likely to choose option **C**, perhaps influenced by the presence of the Roman numerals giving oxidation numbers.

Question 19

A small majority of candidates answered this question correctly, but many chose option **D** instead. Candidates should recall that calcium ions do not form soluble precipitates with any test reagent.

Question 21

This was one of the more demanding questions on the paper with the majority of the candidates choosing option **A.** This suggests that most candidates recall the trend in density of elements in Group VII but are less secure their recall of the trend in density of elements in Group I.

Question 25

In addition to the trend in physical properties, the chemical properties of the elements in Group I were also poorly recalled. Many candidates chose option **C**. Candidates should recall that alkali metals form alkaline solutions when they react with water.

Question 26

Option **B** was the most common incorrect answer. Some candidates were more likely to give any of the other options over the correct answer.

Question 29

This question discriminated well between candidates. Some candidates chose option **B**, assuming that carbon monoxide was a corrosive or acidic pollutant gas. A few candidates chose option **A**.

Question 32

Option **B** was the most common incorrect answer. Candidates should recall that a preservative would need to kill microorganisms. The acidic oxide of sulfur would be used here.

Question 34

This question discriminated well between candidates. Some candidates were more likely to choose one of the incorrect options, with an even split between these options.

Question 39

Overall, candidates appeared to be guessing. This may be because the reactions of ethanoic acid are relatively unfamiliar at core level.

CHEMISTRY

Paper 0620/21
Multiple Choice (Extended)

Question Number	Key
1	D
2	C
3	B
4	B
5	D
6	A
7	B
8	C
9	A
10	A

Question Number	Key
11	D
12	B
13	C
14	B
15	A
16	A
17	C
18	C
19	A
20	C

Question Number	Key
21	B
22	D
23	A
24	D
25	A
26	D
27	D
28	D
29	D
30	B

Question Number	Key
31	B
32	D
33	B
34	C
35	D
36	B
37	A
38	C
39	C
40	C

General comments

Candidates found this to be a challenging paper overall. Questions involving a calculation were not well answered. Questions involving syllabus reactions, particularly those reactions which release a gas, were not well recalled.

Questions 2, **8**, **16** and **28** were found to have the lowest demand. Candidates found **Questions 1**, **10**, **25**, **26** and **37** to have the highest demand.

Comments on specific questions

Question 1

This question discriminated well between candidates. Option **A** was chosen by most of the candidates, which was the reverse of the correct answer. A few candidates chose options **B** or **C**.

Question 9

A small majority of candidates answered this correctly, with others more likely to select option **C**. These candidates missed the 2 : 1 ratio in the equation. Some of the candidates did not determine the limiting reactant and therefore chose option **B**.

Question 10

A few candidates chose option **D**, which is the reverse of the correct answer. Most candidates identified the direction of movement of the electrons in the circuit but did not identify the movement of the positive ions.

Question 13

Candidates often find bond energy calculations challenging. Some candidates appeared to be guessing.

Question 14

A few candidates chose options **C** or **D**, which show less gas being produced at the higher temperature. Most candidates identified the faster reaction at higher temperatures, although some assumed that the faster reaction would produce more gas.

Question 15

This question discriminated well between candidates. Although most candidates identified the effect of temperature on the position of equilibrium, candidates who performed less well overall were more likely to select option **C**.

Question 17

A minority of candidates identified the substance which does not produce a gas. Many candidates chose option **B**.

Question 25

This question on the thermal decomposition of carbonates and nitrates was not well answered. Candidates should recall that the decomposition of carbonates produces carbon dioxide as the only gaseous product. Option **B** was the most commonly selected answer.

Question 26

This question was not well answered. Some candidates confused the extraction of iron with the formation of steel or confused the basic nature of calcium oxide. Options **B** or **C** were chosen by most of the candidates.

Question 31

Option **C** was the most common answer with candidates incorrectly assuming that the formation of oleum requires a catalyst. Candidates should recall both the stages in the Contact process and the name of the catalyst used in the formation of sulfur trioxide.

Question 34

Candidates who performed less well overall were more likely to confuse ethanoic acid and ethanol, selecting option **D**.

Question 36

This question on organic chemistry terminology discriminated well between candidates. A common incorrect choice selected was option **A**.

Question 37

Questions requiring candidates to choose between different pieces of information are often found to be more demanding. Option **C** was chosen by some candidates. Candidates should recall that the addition reaction occurs only at a higher temperature using steam rather than cold water.

CHEMISTRY

Paper 0620/22
Multiple Choice (Extended)

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

General comments

Questions 3, **8**, **27** and **28** were found to have the lowest demand. Candidates found **Questions 9**, **20**, **26**, **34** and **36** to have the highest demand. Questions on organic chemistry showed significant discrimination between candidates.

Comments on specific questions

Question 5

Option **A** was the most common incorrect answer. At this level, candidates would be expected to predict ionic bonding between metallic and non-metallic elements.

Question 6

This question discriminated well between candidates. Many candidates chose option **A**. Candidates should be able to draw dot-and-cross diagrams for all the molecules shown. A quick sketch may aid candidates in answering similar questions.

Question 9

This was a demanding question. Option **B** was chosen by most candidates. This may be related to the question asking for the option which was 'not' correct.

Question 11

Most candidates identified the neutralisation reaction. Confusion between the terms endothermic and exothermic was evident, with option **C** being the most common incorrect answer.

Question 14

This question discriminated well between candidates. Option **B** was a common incorrect choice.

Question 15

A few candidates suggested options **A** or **B**. Many candidates chose option **D**, confusing the highest point and maximum volume with the fastest rate.

Question 20

This question was not well answered. Candidates appeared to ignore or to not understand the relevance of the information given in the stem of the question. Insoluble calcium sulfate would need to be formed by precipitation. The most common answer was option **A**.

Question 22

This was a strongly discriminating question. There was evidence of guessing by some candidates.

Question 26

Candidates should be prepared to recall the order of reactivity and the reactions of each metal. Although relatively few candidates thought that silver would react with steam, a large number thought that it would react with a dilute acid. Option **B** was a common answer.

Question 31

Most candidates narrowed their choice to either options **B** or **C**. Many candidates then thought that the formation of oleum required a catalyst and selected option **C**.

Question 34

Candidates taking the supplement tier are required to be able to draw the structures of organic compounds containing four carbon atoms. A quick sketch would have helped candidates in this question. Overall, the distribution of the choices suggests that many candidates were guessing.

Question 36

Overall, there was a slight preference for the correct answer, but some candidates appeared to be guessing. Candidates should be reminded that alkenes react in addition reactions - this would have allowed them to eliminate half the options in this question.

Question 39

Option **C** was most commonly chosen by candidates who performed less well overall. Candidates should be remined that in organic compounds, carbon forms four bonds, hydrogen one and oxygen two. Hydrogen would therefore not form a double bond and option **C** could be eliminated.

Question 40

Some candidates appeared to be guessing. Questions may be presented in unfamiliar context, in this case the formation of *Kevlar.* Candidates should use the linkages in the structures shown to identify the type of polymer.

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Paper 0620/23
Multiple Choice (Extended)

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

General comments

Candidates performed very well on this paper. Most questions were answered correctly by at least half of the candidates. **Questions 1**, **7**, **8**, **16** and **28** were found to be least challenging. Candidates found **Questions 21** and **39** the most challenging.

Comments on specific questions

Question 2

Candidates should take care to read the full question. Many candidates selected option **B**, which contained a substance with the largest R_f value but did not recognise that this sample was impure.

Question 4

This question discriminated between candidates. Some candidates chose option **D**. This suggests candidates were adding rather than subtracting one electron when counting the electrons in a sodium ion.

Question 6

Candidates are required to be able to draw dot-and-cross diagrams for substances such as methanol. A quickly sketched diagram would have helped candidates. Some candidates appeared to be guessing.

Question 11

Most candidates identified the neutralisation reaction. Confusion was shown between the terms endothermic and exothermic with option **C** being the most common incorrect answer.

Question 13

Most candidates answered this correctly although some selected option **C**. The effect of pressure on the position of equilibrium was less well understood than the effect of temperature.

Question 21

This was one of the more demanding questions on the paper with the majority of candidates choosing option **A**. This suggests that most candidates recall the trend in density of elements in Group VII but are less secure in their recall of the trend in density of elements in Group I.

Question 25

Option **C** was a common incorrect answer. Candidates should take care to read the whole statement. Although potassium does react with water to form hydrogen, candidates should recall that alkali metals form alkaline solutions, not acidic ones.

Question 27

Common incorrect choices were options **B or C**. It should be recalled that hydrogen is not found in clean dry air and so it cannot be extracted from air.

Question 31

Most candidates narrowed their choice to either options **B** or **C**. Many thought that the formation of oleum required a catalyst and selected option **C**.

Question 34

Questions on the nomenclature and structure of esters discriminate well between candidates. Overall, the distribution of answers suggests that some candidates were guessing.

Question 40

Options **C** was chosen by some candidates, suggesting that the presence of nitrogen in an amide bond is not known by all candidates. Option **D** was also a common incorrect choice.

CHEMISTRY

Paper 0620/31
Theory (Core)

Key messages

- Some candidates would benefit by improving their knowledge of specific chemical terms and processes and in writing specific answers.
- Many candidates need more practice in analysing the stem of a question.
- Many candidates need more practice in memorising chemical tests.
- Interpretation of data from tables and completion of chemical equations was generally well done.

General comments

Many candidates tackled this paper well, showing a good knowledge of core Chemistry. The standard of English was generally good. A significant number of candidates did not respond to **Questions 5(c)**, **5(d)(i)(ii)**, **6(a)**, **6(e)(i)(ii)**, **6(f)**, **7(b)(ii)(iv)**, **7(c)** and **8(b)(iii)**.

Some candidates need more practice in writing answers with the correct amount of detail using or explaining specific chemical terms as well as remembering specific chemical reactions. For example, in **Question 1(b)(i)**, few candidates could define cracking. In **Question 2(c)(i)**, many candidates did not know the name of the main ore of iron. In **Question 2(c)(iii)**, many candidates gave vague answers. The sources and effects of oxides of nitrogen were not well known (**Question 5(d)**). Many candidates need more practice in memorising specific chemical reactions mentioned in the syllabus. For example, in **Question 6(a)**, few candidates knew the products of the reactions between acids and metals or metal oxides. The structure of organic functional groups was also not well known (**Question 7(a)(i)**). Only a minority of candidates were able to define a homologous series accurately in Question **7(c)**.

Some candidates need more practice in analysing the stem of a question to pick out the essential words needed to fully answer the question. In **Questions 2(a)(i)** and **(2)(a)(ii)**, some candidates misread the words ‘in the whole Earth’ and gave their answers as if referring to the Earth’s crust. In **Question 2(c)(iii)**, some candidates did not describe the term ‘decomposition’. Candidates should be reminded that if the term to be defined has two words, then both words should be explained. In **Question 3(a)**, many candidates ignored the word ‘solid’ in the stem of the question and gave examples of liquid fuels. In **Question 3(e)(ii)**, many candidates gave answers relating to sources of energy which appeared in the stem of the question. In **Question 5(a)**, some candidates gave the names of compounds rather than elements. In **Questions 6(b)(i)** and **6(b)(ii)**, many candidates ignored the word ‘time’ in the stem of the question and wrote about rate of reaction. In **Question 8(a)**, many candidates did not read the word ‘other’ in the stem of the question and wrote about differences in melting points or boiling points.

Many candidates need to revise practical procedures and qualitative tests for specific ions and molecules. In **Question 1(a)(iii)**, many candidates did not recognise that a C=C bond is involved in the decolourisation of aqueous bromine. The test for chloride ions (**Question 5(c)**) was not well known. Many candidates did not appear to understand the term observations in **Question 6(a)**, giving the names of products instead. A significant number of candidates wrote unclear statements about how to prepare a dry sample of crystals of sodium sulfate from an aqueous solution of sodium sulfate (**Question 6(f)**). Some candidates did not qualify their statements and implied that they were heating to dryness. Others did not give enough information about the drying of the crystals. Those candidates who did, usually suggested drastic conditions such as ‘heating in an oven’.

Many candidates were able to extract information from tables and graphs, balance symbol equations and undertake simple chemical calculations.

Comments on specific questions

Question 1

This question was answered well by some candidates; others had gaps in their basic knowledge of chemistry. For example, many candidates were not able to identify a compound present in acid rain in **(a)(i)** or identify a hydrocarbon that decolorises aqueous bromine in **(a)(iii)**. Few candidates were able to identify the main constituent of natural gas in natural gas in **(a)(v)**. In **(b)(i)**, few candidates were able to state the meaning of the term 'cracking'.

(a) (i) Some candidates identified that compound **B** (sulfur dioxide) is responsible for acid rain. A majority of the candidates chose one of the organic compounds, **C**, **D**, **E** or **F**.

(ii) Many candidates identified **G** as a product of respiration. The most common incorrect answer was **F** (propane).

(iii) A minority of the candidates recognised that **C** (ethene) decolorises aqueous bromine. The most common error was to suggest **F**, the saturated hydrocarbon propane.

(iv) Some candidates were able to identify a carboxylic acid. The most common error was to suggest **E** (ethanol).

(v) Few candidates realised that methane is the main constituent of natural gas. The most common errors were to suggest **C** (ethene) or **G** (carbon dioxide).

(b) (i) Few candidates gave a clear description of cracking. Many answers were too vague, e.g. 'breaking into many parts' or 'a compound is divided into two'. Most candidates did not mention hydrocarbons at all and few referred to the length of the hydrocarbon chain. Others thought that cracking is a separation process, e.g. 'the separation of hydrocarbons' or confused it with distillation, e.g. 'separating the fractions'.

(ii) A majority of the candidates were able to balance the equation correctly. The most common errors were C_4H_{10}, H, or H_2O.

Question 2

This was one of the best answered questions on the paper. Many candidates gave good answers to **(a)(i)**, **(a)(ii)**, **(b)** and **(c)(ii)**. In **(a)(iii)**, many candidates gave vague answers and did not compare specific elements. In **(c)(i)**, only a minority of the candidates knew the name of an iron ore. In **(c)(iii)**, few candidates gave a convincing definition of thermal decomposition. In **(c)(iv)**, few candidates knew the reaction of calcium oxide with impurities in the iron ore. Very few candidates gave a convincing answer about the advantages of recycling iron in **(c)(v)**.

(a) (i) Most candidates deduced the percentage by mass of 'other elements' in the whole Earth correctly. A common error was to misread the stem of the question and give the incorrect answer '1.75' which is the percentage by mass in the Earth's crust. Other common errors were to give answers such as '8' or '9', due to incorrect addition or subtraction.

(ii) Most candidates gave the correct answer 'iron'. The most common error was to suggest 'oxygen' through misreading the stem of the question and selecting the element in the greatest percentage by mass in the Earth's crust rather than in the whole Earth.

(iii) Some candidates gave two differences in the elemental composition of the Earth's crust and the whole Earth. Others did not refer to specific elements and gave vague answers such as 'the percentage of metals is greater in the whole Earth' or 'more gases in the Earth's crust'. Others just quoted figures and did not specify whether the whole Earth or the Earth's crust had a greater percentage of specific elements.

(b) Many candidates were able to draw the electron arrangement of a calcium atom correctly. The most common errors were to draw four electrons in the outer shell instead of two; to draw four electrons in the first and/or second shells or to omit the outer shell electrons.

(c) (i) Few candidates knew the name of an ore of iron. Many gave the name of the compound present in iron ore as 'iron oxide' rather than the name of the ore itself. Others gave the name of elements unrelated to iron, e.g. 'copper' or 'palladium'.

(ii) Most candidates were successful in balancing this equation. The most common errors were to try to balance with 5Fe or 2 or $5CO_2$.

(iii) Few candidates were able to explain the term 'thermal decomposition' accurately. A minority of candidates mentioned 'heat'. Others just wrote 'thermal', which is in the stem of the question. Many candidates wrote about 'separation of substances' or 'burning'. Others suggested 'decomposition of substances', which is in the stem of the question. Candidates should be advised that when there are two words in a term to be defined, both words must be explained.

(iv) Few candidates knew that calcium oxide reacts with impurities in the iron ore, The most common error was to tick the last box (it catalyses the removal of oxygen from iron(III) oxide). Some candidates did not follow the instructions given in the question and ticked two boxes.

(v) Very few candidates gave a good reason why iron should be recycled. The best answers referred to 'conserving the iron ore' or 'less energy is used to produce the iron'. Many answers were too vague, e.g. 'good for the environment' or 'less contamination'. Others paraphrased the stem of the question, e.g. 'can be reused'.

Question 3

This question was well answered by some candidates; others made basic errors in **(a)** to **(d)**. Part **(e)(i)** (radioactive isotope used as a source of energy) was generally well answered**.** Many candidates did not interpret the question about one <u>other</u> use of radioactive isotopes (**(e)(ii)**) correctly.

(a) The most common correct answer was 'coal'. Common incorrect answers included both liquid and gaseous fuels, e.g. 'petrol', 'ethanol', 'petroleum' or 'natural gas'. A few candidates just repeated the word 'fuel' from the stem of the question.

(b) Some candidates did not divide the increase in temperature by the mass of fuel burned. Therefore, the most common incorrect answer was **M** which had the highest increase in temperature.

(c) Better performing candidates suggested 'exothermic'. Many candidates gave vague or incorrect answers such as 'boiling', 'thermal reaction', 'combustion' or 'evaporation'.

(d) Some candidates knew that carbon dioxide and water are the products of the complete combustion of a hydrocarbon. The most common incorrect answer was 'hydrogen', although 'oxygen', carbon oxide' or 'hydroxide' were also seen.

(e) (i) Many candidates selected the correct isotope. The most common error was to select ^{23}Na.

(ii) Many candidates did not read the stem of the question carefully enough and gave answers related to sources of energy, e.g. 'production of electricity' or 'for power'. Others gave medical uses rather than industrial uses, e.g. 'cancer treatment' or 'sterilising medical equipment'.

Question 4

This was one of the best-answered questions on the paper. Most candidates were able to select the correct values in **(a)** and balance the equation in **(b)(i)**. Some candidates gave a good definition of oxidation in **(b)(ii)**. Many candidates gave vague reasons when predicting the physical state of fluorine at 0 °C (**(a)(ii)**). In **(c)**, many candidates did not refer to particles when trying to explain diffusion.

(a) (i) Many candidates gave a suitable value for the melting point of chlorine which was below its boiling point. Fewer candidates gave a suitable value for the density of fluorine. The most common errors were to give a value which was too high, e.g. '0.075' or too low, e.g. '0.000002'.

(ii) The best answers gave the state as 'gas' and the reason as that '0 °C is above the boiling point. A common error was not to refer to the 0 °C at all and just state the values of the melting and boiling points. Other candidates did not gain credit because they wrote that '0 °C is above the melting point'.

(b) (i) Many candidates balanced the equation correctly. The most common errors were to suggest $3F_2$ and/or 2 or 3HF. A few candidates suggested OHF (with the O being oxygen).

(ii) Some candidates gave a good definition of oxidation in terms of gain of oxygen or loss of electrons. Others gave a definition of reduction instead, e.g. 'oxygen is removed'. Others wrote vague or incorrect statements such as 'oxygen is produced' or 'exposed to oxygen'.

(c) A minority of the candidates gained full credit for this question about diffusion. The most common error was not to mention particles at all and just refer to the bromine diffusing. The best answers referred to the random movement of particles and the (overall) movement of particles from areas of high concentration to areas of low concentration. Some candidates did not mention the name of the process (diffusion).

Question 5

This was one of the least-well answered question on the paper. Parts **(b)** and **(d)(ii)** were answered well by some of the candidates. Others gave answers which were far too vague or incorrect. In **(a)**, few candidates gave the names of the other elements found in fertilisers which improve plant growth. In **(c)**, few candidates knew the test for chloride ions. The source and the adverse effects of oxides of nitrogen in **(d)** were not well known.

(a) Some candidates gave the correct answers 'phosphorus' and 'potassium'. A significant number of candidates did not read the question properly and suggested nitrogen which was in the stem of the question. A wide range of incorrect answers were seen, including hydrogen, iron, zinc and fluorine. Other candidates suggested the names of compound ions, e.g. 'phosphates'.

(b) The most common correct answer was 'water'. Some candidates named the salt, calcium chloride, correctly. Others suggested 'calcium oxide' or 'calcium'. 'Chlorine', 'hydrogen' and/or 'carbon dioxide' were other common errors.

(c) A minority of the candidates knew the test for chloride ions. Some candidates incorrectly suggested adding hydrochloric acid (which contains chloride ions) to the sample. The most common error was to suggest 'flame test'. Others suggested 'adding nitrates' or 'distillation', which is not a chemical test. Many candidates did not respond to this question.

(d) (i) Few candidates gave a suitable source of oxides of nitrogen in the air. The most common error was to give vague statements such as 'factories' or 'industrial waste'. Many candidates did not respond to this question.

(ii) Some candidates gave a suitable adverse effect of oxides of nitrogen on heath. Others wrote vague statements such as 'pulmonary disease' or 'the body is not capable of holding it'. Many candidates did not respond to this question.

Question 6

This was one of the least-well answered questions on the paper. The majority of the candidates gained credit for **(c)(ii)** (pH value of an alkaline solution). Some candidates completed the table correctly in **(b)(i)**. Few candidates performed well in **(a)** (chemical reactions of zinc and zinc oxide) and many were unable to describe the correct colour change in **(d)**. In **(e)(i)**, many candidates wrote about the soil rather than the crops or did not write with enough precision. In **(e)(ii)**, only the best answers explained how to prepare pure dry crystals of sodium sulfate from an aqueous solution of sodium sulfate.

(a) A minority of the candidates were able to name the correct products when hydrochloric acid reacts with zinc and with zinc oxide. Common errors for the reaction with zinc included 'oxygen' and 'zinc oxide'. 'Zinc chloride' was the most common correct answer. Common errors for the reaction with zinc oxide were 'zinc' and/or 'hydrogen'. Many candidates did not appear to understand the term 'observations' and gave the names of products instead. The most common correct answer for the reaction with zinc was 'bubbles' or 'fizzing'. Common incorrect answers for the observations with zinc oxide included 'bubbles', 'white precipitate' or 'colour change'. Many candidates did not respond to this question.

(b) (i) Some candidates completed the table correctly. The most common error was to confuse rate with time and give the answers 1.0 mol/dm^3 → 40 s, 0.5 mol/dm^3 → 20 s and 2 mol/dm^3 → 80 s.

(ii) Better performing candidates realised that time taken was inversely proportional to rate. Others confused time with rate and answered in terms of rate, e.g. 'the reaction is slower'.

(c) Most candidates selected a suitable pH for an alkaline solution. The most common errors were to select pH 1 or pH 5.

(d) Some candidates gave the correct colour change from yellow to red. Many candidates did not seem to have read the question properly and suggested red to yellow. Incorrect colours often seen were 'orange' or 'blue'.

(e) (i) Some candidates realised that too acidic conditions would be harmful to the crops or would reduce the growth of crops. Others wrote vague statements about the soil, e.g. 'it affects the pH of the ground' or 'so the soil doesn't contain acids'. Some candidates wrote, incorrectly, about the effects on human health, e.g. 'so humans don't eat an acidic crop'. Many candidates did not respond to this question.

(ii) The best answers referred to 'calcium oxide' or 'calcium carbonate'. Others wrote answers that were too vague, e.g. 'alkali' or 'base'; neither of these is a specific compound as required by the question. Many candidates did not realise that a neutralisation reaction was needed and suggested 'hydrochloric acid' or 'water'. Many candidates did not respond to this question.

(f) The best answers referred to heating the aqueous solution to saturation point, then leaving it to crystallise and drying the crystals using filter paper. The most common errors referred to 'leaving the mixture' or 'heating until a solid is formed'. Few candidates fully described the drying the crystals; an indication of the method of drying, rather than the simple answer 'dry the crystals', was required. Those candidates who gave a method often used methods which were too drastic, e.g. 'heat in an oven' or 'put in a desiccator'. Many candidates did not respond to this question.

Question 7

This was one of the least-well answered questions on the paper. Few candidates recognised the alcohol functional group in **(a)(i)**. More candidates were able to deduce the molecular formula in **(a)(ii)**. Few candidates were able to answer all the questions about ethanol in **(b)** correctly. Many candidates gave answers which were too vague when trying to define the term homologous series in **(c)**.

(a) (i) Few candidates could identify the alcohol functional group. Many candidates included the adjacent C–H group in the circle. The most common error was to put a circle around the COOH group. Very few candidates made the error of putting a circle around the O–H of the COOH group.

(ii) Many candidates could deduce the molecular formula of lactic acid. The most common incorrect answers were C_3H_6O or $C_3H_5O_3$. A significant number of candidates just counted the atoms or did not write a proper formula, e.g. 'C = 3, H = 6, O = 3' or 'H_6 + C_3 + O_3'.

(b) (i) Some candidates realised that ethanol can be manufactured from ethene. The most common error was to suggest 'ethane'.

(ii) Some candidates knew one condition for fermentation. Many answers were too vague, e.g. 'damp' or 'correct temperature'. Some candidates did not appear to understand the term 'condition' and gave the reactant 'glucose'. Others gave the names of a process such as 'evaporation' or 'distillation'. Many candidates did not respond to this question.

(iii) Some candidates gave a suitable use for ethanol. Others did not read the stem of the question properly and suggested the equivalent of fuel, e.g. 'power'. Many candidates gave answers that were too vague, e.g. 'manufacturing' or 'medical treatment'.

(iv) A minority of the candidates knew that the melting point or the boiling point can be used to determine if a sample of alcohol is pure. Others gave vague answers such as 'take its temperature'. The most common errors were to suggest processes such as 'cool it' or 'distillation' (without any further qualification). Many candidates did not respond to this question.

(c) A minority of candidates were able to explain the term 'homologous series' correctly. Hardly any candidates mentioned 'same functional group'. Others just mentioned an example, e.g. 'ethanol is in the alcohol homologous series' or gave incorrect answers such as 'same physical state' or 'series of compounds containing carbon, hydrogen and oxygen'. Many candidates did not respond to this question.

Question 8

This was one of the best answered questions on the paper. Many candidates performed well for **(c)**, **(d)** and **(e)**. In **(a)**, many candidates did not read the word 'other' in the question and gave 'nickel has a higher melting point than sodium'. In **(b)(ii)**, many candidates did not give observations but wrote about the movement of ions. In **(b)(iii)**, few candidates stated a suitable reason for electroplating an object.

(a) Many candidates did not read the word 'other' in the question and wrote about melting points or boiling points. Many candidates referred to the chemical reactivity of nickel and sodium rather than their physical properties, which they were asked for in the question.

(b) (i) Many candidates recognised that the nickel rod acted as the anode. The most common error was to suggest 'cathode'. A few candidates suggested 'electrolyte'.

(ii) Some candidates gave correct answers such as 'prevents corrosion' or 'makes the surface harder'. Others wrote vague answers such as 'to remove impurities' or 'to coat the metal object'. A significant number of candidates wrote about the processes occurring during electroplating, e.g. 'the positive ions are attracted to the cathode'.

(iii) Some candidates gave correct answers such as 'prevents corrosion' or 'makes the surface harder'. Others wrote vague answers such as 'to remove impurities', 'to coat the metal object' or 'to protect from other elements'. Some candidates wrote about the processes occurring during electroplating, e.g. 'the positive ions are attracted to the cathode'. Many candidates did not respond to this question.

(c) The majority of the candidates deduced the number of electrons and neutrons. The most common errors were to suggest 62 or 34 electrons and 62 or 28 neutrons.

(d) The majority of the candidates calculated the relative molecular mass correctly. The most common errors were due to addition errors or not using the correct number of atoms, e.g. one atom of carbon and oxygen' or six atoms of carbon and eight atoms of oxygen.

(e) Most candidates gave the correct order of reactivity. The most common errors were to reverse the series completely or to misplace sodium and magnesium.

CHEMISTRY

Paper 0620/32
Theory (Core)

Key messages

- Some candidates would benefit by improving their knowledge of specific chemical terms and processes and in writing specific answers.
- Many candidates need more practice in analysing the stem of a question.
- Many candidates need more practice in memorising chemical tests.
- Interpretation of data from tables and completion of chemical equations was generally well done.

General comments

Many candidates tackled this paper well, showing a good knowledge of core Chemistry. The standard of English was generally good. Some candidates did not respond to **Questions 1(b)**, **5(c)(ii)**, **7(c)(i)**, **7(c)(iii)**, **7(d)** and **7(e)**.

Some candidates need more practice in writing answers with the correct amount of detail, using or explaining specific chemical terms. For example, in **Question 1(a)(i)**–**(iv)** some candidates did not know the difference between elements and compounds. In **Question 1(c)** many did not know the products of the complete combustion of hydrocarbons. In **Question 2(a)(iii)** some candidates gave vague answers by not specifying elements. In **Question 2(d)(i)** many candidates did not answer specifically enough when describing how oxygen removes carbon from the iron in steelmaking. Others did not fully realise that the components of a mixture are randomly arranged (**Question 2(d)(iii)**) or that the terms 'thermal' or 'heat are required when describing an endothermic reaction (**Question 3(a)**). In **Question 3(b)** most candidates did not consider the amount of fuel burned. Many candidates need more practice in understanding the meaning of general chemical terms or recalling the products of simple chemical reactions. For example, in **Question 4(b)(ii)** some candidates did not know the definition of reduction. In **Question 6(a)** few knew the products of the reactions between acids with carbonates or oxides. The structure of organic chemicals was also not well known (**Question 6(c)(i)**). Many candidates did not understand the meaning of the term 'separation' in the context of particle theory (**Question 7(c)(ii)**). Many candidates need further revision of pollutants, including their effects and sources (**Questions 5(b)(i)** and **5(b)(ii)**). Other candidates need to revise chemical nomenclature. The suffix ending of binary salts, -ide, was sometimes written as -ine.

Some candidates need more practice in analysing the stem of a question to pick out the essential words needed to answer the question. In **Question 3(c)** some candidates ignored the word 'gaseous' in the stem of the question. In **Question 3(e)** many candidates gave answers relating to sources of energy which appeared in the stem of the question. In **Questions 6(e)(i)** and **6(e)(ii)** many candidates ignored the word 'time' and wrote about rate of reaction. In **Question 7(c)(ii)** many candidates either did not know the meaning of the term 'separation' (of particles) or chose to ignore the word and wrote about movement of particles. In **Question 8(a)** many candidates did not read the word 'other' in the stem of the question and wrote about differences in density.

Many candidates need to revise practical procedures and qualitative tests for specific ions and molecules. In **Question 1(a)(iii)** many candidates did not know the test for water. In **Question 1(b)** few candidates knew the test for an unsaturated hydrocarbon. A significant number of candidates did not mention particles in the question about diffusion (**Question 4(c)**) despite being given the prompt about the kinetic particle model. The flame test for potassium (**Question 5(c)(iii)**) was not well known. Many did not appear to understand the term 'observations' in **Question 5(b)** giving the names of products instead. A significant number of candidates wrote unclear statements about how to prepare a dry sample of the salt zinc chloride from zinc oxide and hydrochloric acid (**Question 6(d)**). Some candidates did not qualify their statements and implied that they were heating instead of filtering. Others did not give enough information about drying the crystals. Those that did, usually suggested drastic conditions such as ‘heating in an oven’. Most candidates need more practice in answering questions about observations during chemical reactions which are stated in the syllabus. For example, in **Question 6(a)** most candidates gave answers which stated the reactants and products of the reaction rather than what can be seen or heard during the reaction.

Many candidates were able to extract information from tables and graphs, balance symbol equations and undertake simple chemical calculations.

Comments on specific questions

Question 1

This question was answered well by some candidates; others made basic chemical errors. For example, many candidates did not seem to know the difference between an element and a compound in **(a)(i)**, **(a)(ii)**, **(a)(iii)** and **(a)(iv)**. In **(b)** few candidates were able to describe a test for an unsaturated hydrocarbon. In **(c)** many candidates gave incorrect products for the complete combustion of a hydrocarbon.

(a) (i) Many candidates identified **D** correctly (chlorine atom). The most common error was to suggest **C** (nitrogen) or **G** (an alkene).

(ii) Many candidates identified **B** as the element with a giant covalent structure; others did not read the word element in the question and chose **G** (a covalent compound).

(iii) Some candidates recognised that anhydrous copper(II) sulfate turns blue on addition of water.

(iv) Some candidates were able to identify the element that conducts electricity; others suggested compounds such as **E** (ethanol) or **A** (ethane).

(v) Some candidates recognised **G** as being an unsaturated hydrocarbon; others did not know the difference between an unsaturated and a saturated hydrocarbon and selected **A** (ethane). A wide variety of other incorrect answers were also seen.

(b) Few candidates fully described the correct test for an unsaturated hydrocarbon. Incorrect tests included heating, using a glowing or lighted splint or adding sodium hydroxide. A considerable minority of candidates gave a process rather than a test, e.g. ‘cracking’ or ‘distilling’. Those who selected aqueous bromine or bromine as a test reagent usually knew the reagent is decolourised. A significant number of candidates did not respond to this question.

(c) A minority of the candidates stated the correct products of the complete combustion of a hydrocarbon. The most common errors were to suggest ‘hydrogen’, or ‘carbon’. Many candidates suggested carbon monoxide; the product of incomplete combustion. Other candidates suggested substances whose atoms are not present in a hydrocarbon, e.g. magnesium or aluminium.

Question 2

This was one of the best answered questions on the paper. Many candidates gave good answers to **(a)(i)**, **(a)(ii)**, **(b)** and **(c)(i)**. In **(a)(iii)** many candidates gave vague answers and did not compare specific elements. In **(d)(i)** only a minority of the candidates could explain how the oxygen removes the carbon when making steel. Few candidates chose the correct name in **(d)(ii)** or identified the correct structure of an alloy in **(d)(iii)**.

(a) (i) Most candidates deduced the percentage by mass of ‘other elements’ correctly. The most common error was to suggest 0.35%. Other common errors were to give answers which were incorrect by a one or a few digits, e.g. 2.5%, 4.5% or 5.5%.

(ii) Nearly all candidates gave the correct answer ‘oxygen’. The most common errors were to suggest aluminium or silicon.

(iii) Many candidates gave two differences in the elemental composition of the Earth's and the Moon's crust. Other candidates did not refer to specific elements and gave vague answers such as 'the percentage of metals is greater in the Earth' or 'when the Earth's crust increases, the Moon's crust decreases'. Some candidates just quoted figures and did not specify whether the Earth or the Moon had a greater percentage of specific elements. Another common error was to suggest that the Moon's crust does not contain 'other elements'.

(b) Many candidates were able to draw the electron arrangement of a silicon atom correctly. The most common errors were to draw six electrons in the outer shell instead of four, to draw four electrons in the second shell or to omit the outer shell electrons. A small number of candidates put a positive charge on the top right of the structure, thinking that it was an ion and not an atom.

(c) (i) Most candidates were successful in balancing the equation. The most common errors were to try to balance with 2Fe and $3O_2$, rather than 3Fe and $2O_2$, or 2Fe and $2O_2$.

(ii) Some candidates appeared to guess some of their answers. The most common errors were hydrogen or iron (instead of air), oxidised or decomposed (instead of reduced), monoxide (instead of dioxide) and hydrogen or iron (instead of slag).

(d) (i) Few candidates were able to explain how oxygen removes the carbon. The best answers referred to 'carbon is oxidised' or 'carbon dioxide is formed'. The most common error was to suggest that 'oxygen is more reactive than carbon'. Other common errors included 'oxygen replaces carbon'; 'evaporation' or 'it reacts with iron'.

(ii) Few candidates knew that basic oxides are needed to react with acidic impurities in the iron. The most common error was to select 'hydrocarbon'. Fewer candidates selected the incorrect answer 'acidic oxide'.

(iii) A minority of the candidates selected structure **J**, which shows the atoms close together but with no particular arrangement of the two types of atom. The most common error was to suggest structure **K**, in which there is a regular arrangement of the atoms so that it is not a true mixture. Others suggested structure **L**, which is not the structure of a solid.

Question 3

This question was well answered by only a minority of the candidates. Most candidates were able to label the energy level diagram in **(d)** correctly. Others gave vague answers when describing an endothermic reaction and/or made basic errors in interpreting the table in **(b)**. In **(c)** many candidates did not know the name of a suitable gaseous fuel. In **(e)** many candidates did not read the stem of the question properly and gave uses related to the production of energy.

(a) The best answers included the phrases 'absorbing thermal energy' or 'absorbing heat energy'. Many candidates just referred to energy or suggested that the energy was being released. Others gave vague or incorrect answers such as 'more heat is lost than gained'.

(b) Few candidates divided the increase in temperature by the mass of fuel burned. Therefore, the most commo incorrect answer was **R**, which had the lowest increase in temperature.

(c) Better responses stated 'methane' or hydrogen'. Many candidates suggested liquid fuels such as gasoline or kerosene; others suggested gases which are not generally fuels, e.g. 'nitrogen' or 'ammonia'.

(d) Many candidates were able to complete the energy level diagram correctly. The most common error was to put the products on the left and the reactants on the right. A considerable number of candidates wrote the word 'products' too high up so that it appeared that it related to the downward-pointing arrow. Candidates should be advised to write the words on the line in these diagrams.

(e) A minority of the candidates gave a suitable use for radioactive isotopes e.g. 'cancer treatment' or 'detecting leaks in pipes'. Other candidates did not read the stem of the question carefully enough and gave answers related to sources of energy, e.g. 'production of electricity' or 'for power'.

Question 4

This question was well answered by some candidates. Most candidates were able to balance the equation in **(b)(i),** and many gave correct answers to **(a)(i)** (completing the table) and **(b)(ii)**. Fewer candidates could give a reason for their predicted state of bromine in **(a)(ii)**. Many candidates gave limited explanations in **(c)**.

(a) (i) Many candidates were able to predict the density of iodine. The most common errors were to give a range of values outside the allowed range, e.g. 3.00 to 6.36 or to give values which were too low, e.g. 0.004. Few candidates gave a correct answer for the boiling point of astatine. The most common error was to give a value for the boiling point which was below that of the melting point, e.g. 210 °C. Candidates should be advised to look at the data from both melting and boiling points when answering this type of question.

(ii) The best answers gave the state as 'liquid' and the reason as that 20 °C is between the melting and boiling points. A common error was not to refer to the 20 °C at all and just state the values of the melting and boiling points. Other candidates did not mention both the melting point and the boiling point; others suggested incorrect states such as 'semi liquid' or 'between solid and liquid'.

(b) (i) Many candidates balanced the equation correctly. The most common errors were to suggest $4H_2O$ and/or 4HBr.

(ii) Some candidates gave a good definition of reduction in terms of loss of oxygen or gain of electrons; others gave a definition of oxidation instead. Candidates taking the core paper should be advised to answer in terms of oxygen loss rather than electron gain because many candidates appear to have the wrong idea of reduction in terms of electrons.

(c) A minority of the candidates gained full credit for this question about diffusion. The most common error was not to mention particles and just refer to the hydrobromic acid diffusing. The best answers referred to the random movement of particles and the (overall) movement of particles from areas of high concentration to areas of low concentration. Many candidates did not mention the name of the process (diffusion).

Question 5

This was one of the least well answered questions on the paper. Parts **(a)**, **(b)(ii)** and **(c)(i)** were answered well by some of the candidates; others gave answers which were too vague. In **(b)(i)** few candidates gave a suitable source of oxides of nitrogen. In **(c)(ii)** few could explain the use of fertilisers with sufficient precision. Few candidates knew that the test for potassium involves a flame test and those who did, often gave an incorrect colour for the flame.

(a) Some candidates knew the percentage of nitrogen in clean, dry air. Other candidates realised the rough percentage but gave inaccurate values such as 75%, 72% or 64%. Some gave values which appeared to be guesses, e.g. 30–40%. Fewer gave the value for the percentage of oxygen.

(b) (i) Few candidates gave a suitable source of oxides of nitrogen in the air. The most common error was to give vague statements such as 'factories' or 'burning forests'. A significant number of candidates suggested oxygen or carbon dioxide.

(ii) Some candidates gave a suitable effect of oxides of nitrogen on health; others did not read the stem of the question properly by ignoring the word 'health'. This produced incorrect answers such as 'reacts with rocks or 'used in fire extinguishers'. Many answers were too vague, e.g. 'pollutes the air' or 'affects the lungs'. In the latter answer, it is not clear whether the effect is positive or negative.

(c) (i) Some candidates gave the correct answer 'phosphorus'. A significant number of candidates did not read the question properly and suggested nitrogen or potassium which are in the stem of the question. A wide range of incorrect answers was seen, including hydrogen, sodium and magnesium.

(ii) The best answers referred to 'increased plant growth' or 'to replace nutrients taken from the soil by previous crops'. Many candidates gave answers that were too vague, e.g. 'for crop growth' or 'to supply nutrients to the soil' (no mention of crops or plants). A significant number of candidates thought that fertilisers neutralise the soil.

(iii) Better responses stated that the test for potassium is a flame test. The most common errors were to suggest the addition of ammonia or silver nitrate, with the result being given as 'white precipitate'. Few candidates gave the correct colour for the flame; common errors included 'red', 'yellow' or 'brown'. A significant number of candidates did not respond to this question.

Question 6

This was one of the least well answered questions on the paper. The majority of candidates chose the correct pH in **(c)(ii)** and completed the table correctly in **(e)(i)**. Few candidates performed well in **(a)** (chemical reactions of magnesium carbonate and magnesium oxide) and very few were able to describe how universal indicator can be used to determine pH in **(c)(i)**. In **(d)(ii)** many candidates did not write with enough precision.

(a) A minority of the candidates were able to name the correct products when dilute sulfuric acid reacts with magnesium carbonate and magnesium oxide. Common errors for the reaction with magnesium carbonate included 'hydrogen' and 'magnesium'. Carbon dioxide was the most common correct answer. Common errors for the reaction with magnesium oxide were 'carbon dioxide' and 'hydrogen'. Many candidates did not appear to understand the term 'observations' and gave the names of products instead. The most common correct answer for the reaction with magnesium carbonate was 'bubbles' or 'fizzing'. Common incorrect answers for the observations with magnesium oxide included 'bubbles', 'white precipitate' or 'colour change'.

(b) Some candidates gave the correct colour change from red to blue. Many others did not read the question properly and suggested blue to red. Incorrect colours often seen were yellow or purple.

(c) (i) The best answers stated that the universal indicator had to be added to the acid or acid added to universal indicator paper; many candidates missed this simple point. Few candidates stated that the colour must be compared with the colours on an indicator colour chart. Most gave insufficient answers which tried to relate colour to pH, e.g. 'universal indicator turns red in an acidic solution'.

(ii) Most candidates realised that pH 2 is acidic. The most common errors were to suggest 'pH 7' or 'pH 10'.

(d) (i) Some candidates recognised that the reaction between an acid and alkali is an example of neutralisation. The commonest error was to suggest 'reduction'. 'Polymerisation' was also commonly seen as an incorrect answer.

(ii) The better performing candidates realised that the mixture had to be filtered to remove the excess zinc oxide. The most common errors referred to 'leaving the mixture' or 'wait until the solution evaporates'. These errors probably arose because the candidates did not fully read the next stage of the process which referred to evaporation of the filtrate. Few candidates gained credit for stage six because they did not write with sufficient precision. Some indication of the method of drying was expected rather than the simple answer 'dry the crystals'. Those who gave a method often used methods which were too drastic, e.g. 'heat in an oven' or 'put in a desiccator'.

(e) (i) Many candidates completed the table correctly. The most common error was to confuse rate with time and give the answer 40 °C → 64 s, 20 °C → 16 s and 60 °C → 256 s.

(ii) The better performing candidates realised that time taken was inversely proportional to rate. Other candidates confused time with rate and answered in terms of rate, e.g. 'the reaction is faster'.

Question 7

This was one of the least-well answered questions on the paper. Many candidates recognised the structure in **(a)(i)** as a carboxylic acid and were able to deduce the molecular formula in **(a)(ii)**. Most candidates could define the function of a catalyst in **(b)(i)**. Many candidates correctly identified 'fermentation' in **(b)(ii)**. Few candidates drew the correct structure of ethene in **(c)(i)** or could explain in terms of kinetic particle theory the separation of particles in a gas in **(c)(ii)**. Few candidates were able to explain why long-chain hydrocarbons are cracked in **(c)(iii)**. Most candidates could not name a suitable use for *Terylene* in **(d)** or name a polymer that is a constituent of food in **(e)**.

(a) (i) Many candidates could identify the carboxylic acid. The most common incorrect answer was to suggest 'alcohol'.

(ii) Many candidates could deduce the formula of compound **T**. The most common incorrect answers were $C_5H_6O_3$ or $C_4H_{10}O_2$.

(b) (i) Most candidates were able to state the meaning of the term catalyst. The most common errors included 'it changes reaction rate' and 'it starts a reaction'.

(ii) Many candidates realised that ethanol can be manufactured by fermentation. The most common error was to suggest 'combustion'. A significant number of candidates suggested 'cracking'.

(c) (i) A minority of the candidates drew the correct structure of ethene. The most common errors were to draw the structure of ethane or to draw the structure of ethane but with a double bond. A considerable number of candidates drew hydrogen atoms with two bonds, e.g. C–H–C. A significant number of candidates did not respond to this question.

(ii) The best answers referred to the particles being 'far apart'. Many candidates did not seem to know the meaning of the term separation and wrote about the movement of the particles, e.g. 'they move freely' or 'they vibrate'; others suggested 'diffusion'.

(iii) Correct answers were rare. Some candidates ignored the stem of question and wrote 'to make shorter hydrocarbon chains'. A significant number of candidates did not respond to this question.

(iv) A minority of the candidates referred to 'polyethene' or 'polythene'. The most common error was to suggest 'ethane'. 'Ethyl polymer' was another error frequently seen. Other candidates did not name the polymer and gave a type of polymer instead, e.g. 'addition polymer' or 'polyester'.

(d) A minority of candidates knew a use for *Terylene*. A wide variety of incorrect answers was seen e.g. 'alloys', 'roads' or 'chemicals'. The most common incorrect answer was 'a food substance'. This may have been because the candidates read on to **(e)**, which referred to (other) polymers being a constituent of foods. A significant number of candidates did not respond to this question.

(e) Few candidates were able to name a polymer that is a constituent of food. The most common errors included 'carbohydrate' (instead of polysaccharide or complex carbohydrate), 'polythene' ans 'polyester'. Some candidates gave the names of elements; 'carbon', 'sulfur' or 'calcium' were seen commonly. A significant number of candidates did not respond to this question.

Question 8

This was one of the best answered questions on the paper. Many candidates performed well in **(c)**, **(d)** and **(e)**. In **(a)** many candidates did not read the word 'other' in the question and gave 'chromium has a high density' as an answer. In **(b)(ii)** many candidates gave vague answers.

(a) Many candidates did not read the word 'other' in the question and wrote about density. A common error was to suggest that chromium, rather than chromium compounds, has a colour. Many candidates referred to the characteristics of chromium or potassium which were not really distinguishing properties, e.g. 'chromium is heavier' or 'the relative atomic mass is greater for chromium'.

(b) (i) Many candidates recognised that the nickel rod acted as a cathode. The most common error was to suggest 'electrolyte'. A minority of candidates confused the anode with the cathode.

(ii) Some candidates gave correct answers such as 'prevents corrosion' or 'makes the surface harder'. Other candidates wrote vague answers such as 'to remove impurities' or 'to coat the metal object'. A significant number of candidates wrote about the processes occurring during electroplating, e.g. 'the positive ions are attracted to the cathode'.

(c) The majority of candidates correctly deduced the number of electrons and neutrons. The most common errors were to suggest 54 or 30 electrons and 54, 24 or 18 neutrons.

(d) The majority of candidates calculated the relative molecular mass correctly. The most common errors were in addition or misreading of the formula e.g. '8×16' for oxygen or '1×1' for hydrogen.

(e) Most candidates gave the correct order of reactivity. The most common error was to misplace uranium and chromium.

CHEMISTRY

Paper 0620/33
Theory (Core)

Key messages

- Some candidates would benefit by improving their knowledge of specific chemical terms and processes and in writing specific answers.
- Many candidates need more practice in analysing the stem of a question.
- Many candidates need more practice in memorising chemical tests.
- Interpretation of data from tables and completion of chemical equations was generally well done.

General comments

Many candidates tackled this paper well, showing a good knowledge of core Chemistry. The standard of English was generally good. Some candidates did not respond to **Questions 1(b)**, **3(b)(iii)**, **7(b)(i)**, **7(b)(ii)**, **7(c)(i)** and **7(c)(ii)**.

Some candidates need more practice in writing answers with the correct amount of detail using or explaining specific chemical terms. For example, in **Questions 1(a)(i)**, **(a)(ii)** and **(a)(iv)** some candidates did not know the difference between elements and compounds. Similar errors were seen in **Questions 3(c)(i)** and **5(c)**. In **Question 1(c)(i)**, many candidates could not explain the term 'incomplete combustion'. Many candidates need further revision of the extraction of iron and steelmaking (**Questions 2(c)(i)** and **2(d)(i)**). In **Question 3(a)**, most candidates did not take into account the amount of fuel burned. Many candidates need more practice in learning the meaning of specific chemical terms or the products of simple chemical reactions. For example, in **Question 3(b)(ii)**, many candidates did not know that distillation depends on the boiling points of the components of a mixture. In **Question 5(a)**, few candidates recognised the term displacement. The definition of reduction in **Question 2(c)(iii)** was also not well known. In **Question 6(a)**, few candidates knew the products of the reactions between acids and reactive metals or between acids and carbonates. The structure of organic chemicals was also not well known (**Question 7(a)(i)**). Many candidates did not understand the meaning of the term 'arrangement' in the context of particle theory (**Question 7(a)(iii)**). Many candidates need further revision of pollutants, including their effects and sources (**Questions 5(c)** and **5(d)**). Other candidates need to revise chemical nomenclature. The suffix ending of binary salts, -ide, was sometimes written as -ine.

Some candidates need more practice in analysing the stem of a question in order to pick out the essential words needed to successfully answer the question. In **Question 2(a)(ii)**, some candidates ignored the word non-metal in the stem of the question and/or opted for the lowest percentage by mass rather than the highest. In **Question 3(b)(i)**, some candidates gave answers which repeated the names of the fractions in the stem of the question. In **Question 4(c)** some candidates did not mention 'particles' or named the particles involved.

In **Questions 6(b)(i)** and **6(b)(ii)**, some candidates ignored the word 'time' in the stem of the question and wrote about rate of reaction. In **Question 7(b)(ii)**, many candidates repeated the word 'fermentation' which was in the stem of the question. In **Question 8(a)**, many candidates did not read the word 'other' in the stem of the question and wrote about differences in hardness.

Many candidates need to revise practical procedures and qualitative tests for specific molecules. In **Question 1(b)**, few candidates knew the correct results for the reactions of aqueous bromine with a saturated and an unsaturated hydrocarbon. In **Question 4(b)(ii)**, the best answers referred to the particles being 'far apart'. Many candidates did not appear to know the meaning of the term 'separation' and wrote about the movement of the particles, e.g. 'they move freely' or 'they vibrate'; others suggested 'diffusion'. Many candidates did not appear to understand the term 'observations' in **Question 6(a)**, giving the names of the products instead. In **Question 8(b)(i)**, some candidates wrote about ions moving rather than mentioning the colour change at the cathode or the decrease in size of the copper anode. A significant number of candidates wrote confused statements about how to prepare a dry sample of the salt magnesium chloride from magnesium oxide and hydrochloric acid (**Question 6(d)(i)**). Some candidates did not qualify their statements and implied that they were heating until all that was left was a solid. Others did not give enough information about drying the crystals. Those who did, usually suggested drastic conditions such as 'heating in an oven'.

Many candidates were able to extract information from tables and graphs, balance symbol equations and undertake simple chemical calculations.

Comments on specific questions

Question 1

This question was answered well by some candidates; others made basic chemical errors. For example, many candidates did not seem to know the difference between an element and a compound in **(a)(i)**, **(a)(ii)** and **(a)(iv)**. In **(b)**, few candidates were able to describe the observations when aqueous bromine is added to saturated and unsaturated hydrocarbons. In **(c)(i)**, most candidates gave too vague a definition of incomplete combustion. In **(c)(ii)**, a minority of the candidates gave a suitable effect of carbon monoxide on health.

(a) (i) Many candidates identified **D** correctly (phosphorus atom). A wide range of errors were seen, mainly **A**, **C**, **E** and **F**.

(ii) Some candidates identified **G** as the element with a giant covalent structure. Others did not heed the word 'element' in the question and chose **D** or **B**, which are covalent compounds.

(iii) Many candidates recognised that diamond is used in cutting tools. The most common error was to suggest **F** (sulfur trioxide), which is a compound, not an element.

(iv) Some candidates were able to identify the compound that is a major contributor to climate change. The most common error was to select **F** (sulfur trioxide).

(v) Some candidates recognised **A** as being a saturated hydrocarbon. Some candidates did not know the difference between an unsaturated and a saturated hydrocarbon and selected **C** (propene); others selected **E** (methanol).

(b) Few candidates could fully describe the correct observations on addition of aqueous bromine to a saturated and an unsaturated hydrocarbon. Many candidates suggested incorrectly that the saturated hydrocarbon decolourised aqueous bromine and the unsaturated hydrocarbon did not. Others gave vague answers such as 'soluble' and 'insoluble' or 'reacts fast' and 'reacts slow'. A few candidates gave vague answers for the unsaturated hydrocarbons being decolourised e.g. 'transparent', 'clear' or 'discoloured'. A significant number of candidates did not respond to this question.

(c) (i) Few candidates were able to explain the meaning of the term 'incomplete combustion'. The best answers referred to 'combustion in limited amounts of air' or 'not enough air to burn completely'. Common errors were 'unfinished breakdown of hydrocarbons', 'combustion is not finished', 'the compound hasn't burnt yet' or 'combustion in the absence of air'.

(ii) The best answers were 'poisonous' or 'toxic'. Many candidates gave answers more apposite to oxides of nitrogen, e.g. 'damages lungs' or 'breathing difficulties'. Others did not mention an effect but gave a reason such as 'binds to haemoglobin'. Another common error was to suggest 'cancer'.

Question 2

This was one of the best answered questions on the paper. Many candidates gave good answers to **(a)(i)**, **(a)(ii)**, **(b)** and **(c)(ii)**. In **(a)(iii)**, some candidates gave vague answers and did not compare specific elements. In **(c)(i)**, only a minority of the candidates could explain why air is blown into the blast furnace. In **(c)(iii)**, some candidates were able to define reduction; others confused this with oxidation. In **(d)(i)**, few candidates identified the two substances used in the conversion of iron into steel. In **(d)(ii)**, only a minority of the candidates defined the term 'alloy' correctly.

(a) (i) Most candidates deduced the percentage by mass of 'other elements' correctly. The most common error was to suggest 1.9 or 2.9 due to simple addition errors.

(ii) Most candidates gave the correct answer 'oxygen'. The most common errors were due to misreading the stem of the question. The most common incorrect answer was 'iron' (which is a metal rather than the non-metal requested). Another common incorrect answer was 'hydrogen' (a non-metal with the lowest, not the highest, percentage by mass).

(iii) Many candidates gave two differences in the elemental composition of the whole Earth and the oceans. Others did not refer to specific elements and gave vague answers such as 'the oceans are strongly built around hydrogen and oxygen' or 'the percentage by mass in the oceans is three times higher than the percentage by mass in the whole Earth'. Some candidates just quoted figures and did not specify whether the whole Earth or the oceans had a greater percentage of specific elements. Another error was to suggest that the oceans do not contain 'other elements'.

(b) A majority of the candidates were able to draw the electron arrangement of a chlorine atom correctly. The most common errors were to draw six electrons in the outer shell instead of seven, to draw four electrons in the innermost shell or to omit the innermost shell electrons.

(c) (i) Most candidates gave answers which were imprecise such as 'to remove carbon'. Others gave answers which referred to the iron oxide rather than the carbon, e.g. 'to remove oxygen from the iron oxide' or 'to react with the iron'.

(ii) Nearly all the candidates balanced the equation correctly. The most common error was to add an oxygen to the carbon monoxide as OCO.

(iii) Some candidates gave a good definition of reduction in terms of loss of oxygen or gain of electrons; others gave a definition of oxidation instead. Candidates taking the core paper should be advised to answer in terms of oxygen loss rather than electron gain because many candidates appeared to have the wrong idea of reduction in terms of electrons.

(iv) Most candidates did the calculation correctly. The most common error was 9.8, obtained by $\frac{56}{80} \times 14$.

(d) (i) Few candidates identified the two substances used in the conversion of iron into steel. The most common errors were silicon(IV) oxide, hydrogen or carbon dioxide.

(ii) The best answers referred to 'a mixture of a metal with other elements'. Many candidates omitted the word mixture and some suggested that alloys are compounds or contain compounds. Others suggested that alloys are 'mixtures of elements'. Candidates should be advised that an alloy always contains a metal.

Question 3

This question was one of the least-well answered on the paper. In **(a)**, many candidates did not read the question properly and ignored the mass of fuel burned. In **(b)(i)**, many candidates did not heed the word 'other' in the stem of the question. In **(b)(ii)**, many did not know that fractional distillation depends on differences in boiling point of the components. In **(c)(ii)**, many candidates did not heed the word 'other' or the word 'industrial' in the question and gave answers relating to energy or medicine.

(a) Few candidates divided the increase in temperature by the mass of fuel burned. Therefore, the most common incorrect answer was **K**, which had the highest increase in temperature**.**

(b) (i) Some candidates did not read the question properly and suggested fractions which were mentioned in the stem of the question. Some suggested 'gasoline', being swayed by the 'gas' part of this word; other incorrect answers included 'kerosene' and 'bitumen'.

(ii) A minority of the candidates realised that distillation depends on differences in the boiling points of the different components of the mixture. The most common incorrect answers included 'density', 'liquid'. 'high (or low) temperature' and 'solubility'.

(iii) Some candidates knew that bitumen is formed at the bottom of the fractionating column. The most common error was to suggest that the bitumen fraction comes off one or two pipes above the lubricating fraction. A significant number of candidates did not respond to this question.

(c) (i) Some candidates knew that uranium is used in the production of energy in nuclear power stations. A wide variety of incorrect answers were seen, these included 'fluorine', 'titanium', 'argon' and 'carbon dioxide'. Some candidates did not name an element as instructed and gave answers such as 'nuclear' or 'gamma radiation'.

(ii) A minority of the candidates gave a suitable industrial use for radioactive isotopes e.g. 'detecting leaks in pipes'. Others did not read the stem of the question carefully enough and gave answers related to sources of energy, e.g. 'production of electricity' or 'for power' or gave non-industrial uses, e.g. 'cancer treatment'.

Question 4

This question was one of the best-answered questions on the paper. Most candidates were able to balance the equation in **(b)(i)** and many gave correct answers to **(a)(i)** (completing the table). Fewer candidates knew the test for hydrogen in **(b)(ii)**. In **(c)**, some candidates did not write about particles.

(a) (i) Many candidates were able to predict the boiling point of sodium and the hardness of rubidium. The most common errors were to suggest too low a boiling point for sodium, e.g. 140 °C or too high a hardness for rubidium, e.g. 17.6 MPa.

(ii) The best answers gave the state as 'solid' and the reason as '50 °C is below the melting point'. Weaker answers stated that 'it's between the melting and boiling points'.

(b)(i) Many candidates balanced the equation correctly. The most common errors were to suggest 1Na and/or $3Na_2O$.

(ii) Some candidates knew the test for hydrogen. Some candidates confused the test with that for oxygen and suggested using a glowing splint. Other common errors included vague statements such as 'splint test', 'heat' or 'use a flame'. The most common incorrect results were to suggest that 'the splint reignites' or 'the splint goes out'.

(c) The most common error was not to mention particles at all and just refer to the 'alizarin diffusing'. The best answers referred to the random movement of particles and the (overall) movement of particles from areas of high concentration to areas of low concentration. Some candidates did not mention the name of the process (diffusion).

Question 5

Some candidates answered this question well; others made simple chemical errors or confused aspects of environmental chemistry. Part **(b)(i)** was answered well by many candidates. In **(a)**, few candidates recognised the reaction as being a displacement. In **(c)**, many candidates did not read the stem of the question carefully enough and suggested 'nitrogen' or gave the name of compounds rather than elements. In **(d)(i)**, few candidates named a pollutant, other than oxides of nitrogen, that is responsible for acid rain.

(a) Some candidates knew that the reaction was a displacement reaction. The most common incorrect answers were 'reduction' or 'oxidation'.

(b) (i) Many candidates knew the symbol for a reversible reaction. The most common errors were to suggest 'equals', 'reverse reaction' or 'exchange'.

(ii) Some candidates remembered the percentage of nitrogen in clean, dry air correctly. Some candidates realised the rough percentage but gave inaccurate values such as 79%, 73% or 70%. Others gave values which appeared to be guesses, e.g. 2%. Few candidates gave the value for the percentage of oxygen.

(c) Some candidates gave the correct answers ‘phosphorus’ and ‘potassium’. A significant number of candidates did not read the question properly and suggested ‘nitrogen’. A wide range of incorrect answers were seen, including ‘iron’, ‘hydrogen’ or ‘oxygen’. Other candidates did not heed the word element in the stem of the question and suggested the names of compounds, e.g. ‘sodium chloride’ or ‘carbon dioxide’.

(d) (i) Many candidates thought that carbon dioxide is responsible for acid rain. Candidates should be advised that, although carbon dioxide is slightly acidic, it is not acidic enough to be classed as a compound responsible for the effects of acid rain. Other common incorrect answers included ‘methane’, ‘sulfur’ or ‘carbon monoxide’.

(ii) Better performing candidates gave answers that referred to ‘chemical erosion’ or ‘pitting of the surface of the building’. Others gave vague answers such as ‘rusts buildings’ or ‘affects the quality of the building’. A considerable minority of candidates suggested drastic effects such as ‘destroys the building’ or ‘the building breaks down’.

Question 6

A majority of the candidates performed well in **(b)(i)** (time taken for a reaction to finish), **(c)(ii)** (pH of an alkali) and **(d)(ii)** (function of a catalyst). Fewer candidates successfully answered **(a)** (chemical reactions of magnesium and magnesium carbonate). Only the better performing candidates were able to describe the effect of concentration on the time taken to finish a reaction in **(b)(ii)**. In **(d)(i)** (salt preparation), many candidates wrote statements that were too vague.

(a) Some candidates were able to name the correct products when dilute hydrochloric acid reacts with magnesium and magnesium carbonate. Common errors for the reaction with magnesium were ‘water’ or ‘oxygen’. Magnesium chloride was the most common correct answer. The most common error for the reaction with magnesium carbonate was ‘hydrogen’. Many candidates did not appear to understand the term ‘observations’ and gave the names of the products instead. The most common correct answer for the reaction with magnesium was ‘bubbles’ or ‘fizzing’. Common incorrect answers for the observations with magnesium carbonate included ‘white precipitate’ or ‘colour change’.

(b) (i) Many candidates completed the table correctly. The most common error was to confuse rate with time and give the answer as large → 30 s, very small → 200 s and small → 90 s.

(ii) Better performing candidates realised that time taken was inversely proportional to rate. Others confused time with rate and answered in terms of rate, e.g. ‘the reaction is slower’.

(c) (i) Some candidates gave the correct colour change from red to yellow. Many others did not read the question properly and suggested yellow to red. Incorrect colours often seen were ‘green’ or ‘blue’. A significant number of candidates wrote ‘orange’, being swayed by the name of the indicator.

(ii) Most candidates identified the correct pH value for an alkaline solution. The most common error was to suggest pH 7.

(d) (i) The best answers referred to ‘heating to the point of crystallisation and then leaving’ or ‘evaporating until a saturated solution is formed’. The most common errors referred to ‘heating’ (unqualified) or ‘heating until a solid is formed’. Others wrote vague statements such as ‘allow the crystals to form’. In stage six, many candidates did not write with sufficient precision. An indication of the method of drying was expected rather than the simple answer ‘dry the crystals’. Those who did give a method often used methods which were too drastic, e.g. ‘heat in an oven’ or ‘put in a desiccator’.

(ii) Most candidates gave a suitable definition of a catalyst. The most common errors were to suggest that ‘it starts a reaction’ or ‘it changes the rate of reaction’. Candidates should be advised that catalysts increase the rate of reaction.

Question 7

Some candidates recognised the carboxylic acid functional group in **(a)(i)** and deduced the formula in **(a)(ii)**. Fewer candidates were able to draw the structure of ethanol in **(b)(i)** or to describe another method of manufacturing ethanol in **(b)(ii)**. In **(c)(i)**, some candidates knew that the small units used to make polymers were called monomers. Very few candidates were able to name a natural polymer in **(c)(ii)**. A greater number of candidates were able to describe a pollution problem caused by non-biodegradable plastics in **(c)(iii)**. Others gave answers which were too vague.

(a) (i) Many candidates could identify the carboxylic acid functional group. The most common incorrect answers were to draw the circle to include the CH group next to the COOH group or to circle the OH or C=O groups.

(ii) Many candidates could deduce the formula of compound **S**. The most common incorrect answers were $C_4H_6O_2$ or C_3H_5COOH.

(iii) The best answers referred to the particles being 'regularly arranged'. Many candidates did not appear to know the meaning of the term' arrangement' and wrote about the movement of the particles, e.g. 'they vibrate'. Others gave vague answers such as 'no space to move' or 'fixed positions'.

(b) (i) Some candidates were able to draw the structure of ethanol showing all of the atoms and all of the bonds. The most common errors were to omit the O–H bond, to draw the structure of a different alcohol (especially methanol or propanol) or to draw the structure of ethane. A significant number of candidates did not respond to this question.

(ii) Some candidates did not read the stem of the question properly and suggested 'fermentation'. Others appeared to guess and gave incorrect answers such as 'cracking', 'fractional distillation' or 'anaerobic respiration'. Others misread the question and described the conditions for fermentation. A significant number of candidates did not respond to this question.

(c) (i) Some candidates gave the correct name, monomers, to the small units which join together to form polymers. The most common errors were to suggest 'macromolecules', 'molecules' or 'polymerisation'. Others suggested the names of specific molecules such as 'ethene'. A significant number of candidates did not respond to this question.

(ii) Many candidates did not seem to know the meaning of the term 'natural polymer' and gave the name of a synthetic polymer such as 'terylene' or 'nylon'. Others gave the names of elements, e.g. 'potassium' or 'sulfur'. A significant number of candidates did not respond to this question.

(iii) Some candidates wrote good answers, referring to 'blockage of drains', 'strangulation of sea creatures in discarded fishing nets' or 'filling of landfill sites'. Those who mentioned poisonous fumes often did not gain credit because they omitted the essential detail that the plastic needs to be burned to release these fumes. Many candidates wrote statements that were too vague, e.g. 'land pollution', 'air pollution' or 'not recyclable'.

Question 8

This was one of the best answered questions on the paper. Many candidates performed well in **(c)**, **(d)** and **(e)**. In **(a)**, many candidates did not read the word 'other' in the question and gave answers such as 'copper is harder' or 'sodium is softer'. In **(a)(ii)**, many candidates gave answers which were too vague. In **(b)(ii)**, many candidates did not give observations, but instead gave information about changes to the electrolyte or details about the movement of ions.

(a) (i) Many candidates did not read the word 'other' in the question and wrote about hardness. A common error was to suggest that copper, rather than copper compounds, has colours. Many candidates referred to the characteristics of copper or sodium which were not distinguishing properties, e.g. 'copper is heavier' or 'the relative atomic mass is greater for copper'. Other candidates suggested properties for which they could not know the relative values, e.g. electrical conduction or properties that are common to both metals, e.g. lustre.

(ii) The best answers referred to electrical wiring. Many candidates simply suggested 'wires' which was considered too vague. Others suggested answers which were also not specific enough, e.g. 'building houses'.

(b) (i) Most candidates labelled the diagram correctly. The most common errors were to label the cathode as the anode, to label the positive pole of the battery or the wires as the anode.

(ii) Many candidates did not appear to understand the meaning of the term 'observations' and wrote about ions moving in the electrolyte or the movement of electrons. Others wrote comments such as 'copper coats the spoon'. Those who mentioned a copper colour or pink colour seen on the spoon gained credit.

(c) A majority of the candidates performed well. The most common error was to suggest 65 electrons. Nearly all the candidates deduced the correct number of neutrons.

(d) Nearly all the candidates performed well. The most common errors were errors in addition.

(e) Nearly all candidates gave the correct order of reactivity. The most common error was to invert lanthanum and zinc. A few candidates did not understand the table and wrote 'metal' (the table heading) in place of one of the named metals.

CHEMISTRY

Paper 0620/41
Theory (Extended)

Key messages

- Ionic equations, including half-equations, continue to be an area that needs considerable improvement.
- Where candidates are required to select an answer from a set of choices, such as **Question 1**, candidates should be encouraged to make sensible guesses rather than leaving an answer blank.
- Candidates should not provide fractions as answers to calculations.
- When determining the *M*r of a substance, candidates should clearly state that the number they have determined is in fact the *M*r, rather than a random number.
- More precision is needed when drawing arrows on an energy profile diagram.
- Subscripts must be written below the line e.g. CO_2 as opposed to CO2. This applies to writing general formulae e.g. C_nH_{2n+2} as opposed to CnH2n+2.

General comments

Candidates appeared to have sufficient time for all questions to be answered. When drawing diagrams to support a written response, candidates should check that they are labelled clearly and do not contradict their written text. Very few candidates felt the need to write on extra pages. If extra pages are used, any responses must be clearly show which question they refer to.

Comments on specific questions

Question 1

(a) This question was answered well with most candidates choosing oxygen as the product of photosynthesis; the most common error was carbon.

(b) Fewer candidates answered this well. A common error was to choose nitrogen as the oxide found in clean dry air.

(c) This question was answered less well with many candidates unable to recall that metals formed basic oxides.

(d) This question was answered very well with the majority of candidates knowing nitrogen was the main component of fertilisers.

(e) Candidates found this question challenging with the majority choosing fluorine, oxygen or nitrogen. Few candidates realised that these gases exist as diatomic molecules and thus chose neon as the gas with the highest rate of diffusion.

(f) This question was answered well with many candidates able to recall that lithium produces a red flame.

(g) The majority of candidates were able to recall that boron has 5 electrons in its outer shell.

(h) About half of the candidates realised that nitrogen was responsible for acid rain; the most common error was carbon.

Question 2

(a) Candidates found this challenging with many candidates describing ionic bonding as opposed to metallic bonding.

A description of a 'sea of electrons' or 'delocalised electrons' was often correctly stated. However, a common phrase was 'free' electrons which is not the same as saying the electrons are mobile. Common errors included protons and nuclei rather than positive ions; negative ions (sometimes in a 'sea') rather than electrons and omitting the attraction between oppositely charged particles. Many omitted the idea that the positive ions were held in a lattice. Another common phrase was 'there is a force' between the particles without stating that it is a force of *attraction* that exists between the oppositely charged particles.

Atoms, molecules, and intermolecular forces were seen often.

(b) (i) Many candidates found it challenging to distinguish between physical and chemical properties.

(ii) Some candidates were only able to give the correct charges. Candidates who performed less well did not attempt to draw the outer shell for either the sulfide or the potassium ions. If they did, they only used dots to fill the outer shell of the sulfide ion. This demonstrated a lack of understanding of the concept of electron transfer from potassium.

(c) (i) Many candidates were able to recall that potassium produces a lilac flame.

(ii) Hydroxide ion was known by most candidates. A common error was to miss the charge from the ion or include other ions such as K^+.

(iii) This was well answered, and the majority of candidates could recall that litmus is blue in alkali. A small number stated that litmus is purple in alkali, showing some confusion with universal indicator.

(iv) Candidates could carry out the first two steps of this calculation, accurately finding the moles of potassium added and hydrogen formed. A small number of candidates used an incorrect mole ratio. Quite a few candidates quoted their final answer in dm^3 and not cm^3 as required from the stem of the question.

(d) (i) The most common answer here was HCl but the stem of the question required a name of an acid which is an aqueous species.

(ii) Many candidates could recall that the method of salt formation is neutralisation; the most common error was 'exothermic'.

(iii) Candidates found this difficult, with few candidates recalling that titration is the method of salt formation. The majority of candidates stated the purification technique of crystallisation as a method of salt formation.

(e) (i) This was answered well and most candidates could recall the precipitate formed would be white.

(ii) About half of the candidates could name the precipitate as silver chloride. The most common error was to name the soluble potassium nitrate as the precipitate.

(iii) Candidates found this challenging. Many attempted a symbol equation instead of an ionic equation, or a mixture of both, but could identify that silver chloride was produced in the reaction. In an ionic equation for a precipitation reaction, the two ions in aqueous solution that react to form the precipitate are aqueous and on the left-hand side; the solid precipitate is on the right-hand side. This was known to only a small number of candidates.

Question 3

(a) The Haber process was generally well known.

(b) Many candidates were able to recall that air was the source of nitrogen. A few stated, incorrectly, that methane or natural gas was the source. A small number stated 'atmosphere' which is not the same as air.

(c) The reversible symbol was well known. A few candidates stated that the symbol meant equilibrium.

(d) The conditions were well known. A small number of candidates stated the pressure for the Contact process as opposed to the Haber process.

(e) Iron was well known. The most common error was Vanadium(V) oxide.

(f) This was answered poorly. Better performing candidates stated:
Temperature is reduced:

- the forward reaction is exothermic
- therefore, the equilibrium shifts / moves to the right-hand side when the temperature is increased.

and
Pressure is reduced:

- the equilibrium shifts / moves to the left-hand side
- to the side with fewer gaseous moles.

There were a lot of references to the equilibrium breaking and that the reaction would go forward.

As equilibrium reactions are reversible, candidates need to say that the equilibrium moves / shifts backwards rather than 'goes forwards'. The equilibrium shifts to the endothermic side is not sufficient as the candidates must state which direction the reaction is shifting. Several candidates referred to the reaction having less moles as opposed to the 'side' having the fewest moles.

(g) It was very common for candidates to ignore the question remit and instead choose to describe the more familiar scenario of how a temperature increase affects the rate of reaction. A very brief temperature decrease effect was sometimes given at the end of the response.

Of those candidates who fully described the effect of a temperature decrease, most stated that particles have less energy. However, many wrote 'there are fewer collisions' rather than stating that the frequency of collisions decreases. It was rare to see the statement that a smaller proportion (or lower percentage) of collisions have enough energy to produce a reaction. 'Fewer collisions having enough energy to produce a reaction' is insufficient.

(h) Few candidates could produce the correct formula for ammonium sulfate.

Question 4

(a) Candidates found this question challenging, with many not realising that carbon dioxide was a product of a carbonate reaction.

(b) Many of the answers had ignored the instruction to give observations. Where candidates could identify the correct products, they often did not state what would be observed. Many observations were vague such as 'a colour change is seen', or 'a salt is formed'. Observations need to be visible changes, such as the solid disappears or dissolves or becomes smaller.

(c) Many candidates could recall the term filtrate with the most common error being residue. Several candidates stated 'filtered', but this is a term for the process not the solution collected.

(d) (i) Many candidates attempted to use the correct terminology of solute, solvent and dissolve but often confused the terms; for example 'solvent dissolving in solute' was regularly seen. It was common to see answers given in reference to saturation of organic compounds, rather than saturated solutions.

(ii) Many candidates referred to the evaporation of water to form crystals rather than the process of leaving them to cool.

(e) (i) Few candidates could recall the term anhydrous; commonly quoting 'dehydrated' or 'unhydrous' as alternatives.

(ii) Generally, the *M*r was calculated correctly. However, when determining the *M*r of a substance, candidates should clearly state that the number they have determined is in fact the *M*r, rather than a random number. In the majority of cases, most of the candidates could calculate the number of moles of nitrate correctly. Only a small number of candidates could apply the mole ratio correctly to find the moles of water of crystallisation.

(f) This question was designed to stretch the most able candidates. Many candidates found this very challenging with only a few being able to recall that a nitrite was made on the decomposition of a nitrate.

Question 5

(a) The majority of candidates were able to correctly state the general formula of alkenes. A few candidates confused the formula with that of alkanes and some candidates incorrectly stated $C_n + H_{2n.}$

(b) Some candidates confused the colour change as being colourless to orange.

(c) Candidates were able to recall the term addition.

(d) (i) The majority of candidates drew the horizontal line to the right-hand side and below the reactants line and labelled this $C_2H_4Br_2$. A few just labelled this line 'products'.

Care should be taken drawing the activation energy arrow from the level of the reactants to the top of the 'hump'. Many arrows finished too short of the top of the hump and some candidates simply labelled the top of the 'hump' as activation energy.

Some candidates incorrectly drew a double headed arrow for the energy change as opposed to the downward pointing arrow showing an exothermic reaction.

(ii) This calculation was done very well by the majority of candidates who produced a correct answer of –130 kJ / mol. The most common error was +130 kJ / mol.

Question 6

(a) (i) Some candidates were able to correctly name the ester.

(ii) There was some confusion with the term 'empirical formula', with many candidates stating the molecular formula for the ester.

(b) Many very good answers were seen. The most frequent error was the omission of the non-bonding electrons on the oxygen atoms. A few candidates showed the bonding electrons as dative bonds.

(c) Very few correct responses were seen. Candidates were required to show every atom and every bond in their diagram. Many opted to omit the bond between the oxygen and hydrogen in the alcohol functional group. Candidates also need to consider the valences of the atoms drawn; divalent hydrogen atoms and pentavalent carbon atoms were commonly seen in the structures drawn.

(d) Many could define the term structural isomer well.

(e) Very few correct responses. There were no common errors.

CHEMISTRY

Paper 0620/42
Theory (Extended)

Key messages

- Candidates should not use charges when writing chemical equations.
- Candidates should not provide fractions as answers to calculations.
- When determining the M_r of a substance, candidates should clearly state that the number they have determined is in fact the M_r, rather than a random number.
- Candidates need to consider the valencies of atoms; divalent hydrogen atoms and pentavalent carbon atoms were commonly seen in the structures drawn.

General comments

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

The standard of calculation work seemed better than in previous series.

Comments on specific questions

Question 1

(a) Most candidates knew that there were four bonds in diamond, although there were several other suggestions.

(b) The correct term 'giant covalent' was frequently seen.

Common incorrect or incomplete responses were: 'giant' and 'giant lattice' both of which did not include the covalent nature of diamond. Weaker responses described properties of diamond such as 'strong' and 'hard' rather than the structure.

(c) Silicon(IV) oxide or silicon dioxide was known by most candidates.

(d) The idea of graphite having layers of atoms was well known. Less well described was the hexagonal arrangement of atoms within these layers.

(e) Most candidates were aware that mobile electrons allow graphite to conduct electricity. The term 'free electrons' gained no credit.

(f) Candidates coped well with this calculation and 60 was frequently seen. 120 was a common error.

(g) The use of limewater to test for carbon dioxide was well known.

Question 2

(a) Weaker responses simply repeated the information given in the question that ‘sodium is a reactive metal’ with no further information offered. Better responses appreciated that sodium is stored under oil to prevent reaction with oxygen and / or water. ‘Air’ and ‘moisture’ were acceptable alternatives.

(b) (i) ‘Oxidation’ was seen more frequently than the correct response ‘combustion’.

(ii) A selection of incorrect colours was seen in some responses.

(iii) The symbol of sodium and the formula of sodium oxide were given in the question. Better performing candidates were able to include O_2 as a reactant and correctly balance the equation. Others gave an equation with correct formulae but balanced it incorrectly. Some candidates opted to give their own formula of sodium oxide, despite Na_2O being given.

(iv) For many candidates, the charge was the only correct response given. Common errors were to show the eleventh electron on the sodium ions, to add a third shell to the oxide ion or to show eight dots instead of six dots and two crosses in the oxide ion’s outer shell.

(c) (i) The syllabus definition of a base as a proton acceptor was well known.

(ii) The question asked for a pH number to be given, i.e., one number should be given. Many candidates opted to give a range of numbers, which was acceptable if the range indicated the pH was only within the range 12 to 14. Candidates who wrote ‘above pH 12’ were not given credit as, for example, this could include pH 16.

(iii) Relatively few candidates knew that methyl orange was yellow in alkaline conditions. The most common error was ‘pink’. Many candidates wrote a mixture of colours, e.g., red / yellow.

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

Candidates should also be reminded that leaving the M_r calculation as a sum, e.g. M_r(NaOH) = 23 + 16 + 1 may also not receive full credit.

The most common error was to determine the moles of Na by dividing 0.345 g by 46 (46 is twice the A_r of Na), presumably due to the stoichiometric coefficients given in the equation.

(d) (i) Relatively few candidates knew the term for making an insoluble solid from solutions of two aqueous solutions was ‘precipitation’.

(ii)(iii) Neither the colour (red-brow) nor name of the insoluble solid (iron(III) hydroxide) formed were well known. White was the most frequent colour error and sodium chloride was the most frequent error when attempting to identify the insoluble solid.

(iv) Candidates continue to struggle with ionic equations for precipitate formation. Ionic equations will always have two reactant *ions* and one product compound. The sequence of state symbols will always be (aq) + (aq) → (s). Many candidates attempted to write the complete symbol equation. Candidates might be advised to identify the solid product and ‘split’ this up into its constituent ions. These will be the reactants.

Question 3

(a) Few candidates knew that zinc blende was usually the ore used in this process. Many compounds containing sulfur, and many that do not, were suggested

(b) This question had a wide range of incorrect responses with vague statement processes involving oxygen as opposed to air. Roasting in air was rarely seen.

(c) The name ‘Contact process’ was well known, although many thought it was the ‘Haber process’.

(d) (i) Most candidates gained full credit. Others gave a range of values with some of the range being outside acceptable values. Candidates should be advised to give single values only. Frequently, values associated with the Haber process were seen.

(ii) Vanadium(V) oxide was very well known as the catalyst, although an incorrect oxidation number of vanadium was often seen.

(iii) Many candidates wrote vague statements such as 'forward rection equals backward reaction' and did not mention rates. A very common error in the second part of the question was stating 'concentration of reactants and products are equal'. Relatively few correctly stated 'concentration of reactants and products are constant'.

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

More candidates could give a correct explanation than describe what happened to the position of equilibrium. Many irrelevant comments about rate changes were seen. Candidates should be aware that there is no such thing as an 'endothermic side' to a reaction. There is an 'endothermic *direction*', however.

(v) Most candidates knew that particles gain more energy. Many candidates omitted the most obvious comment that the rate increases. Many stated that the *frequency* of collisions increases, although many candidates wrote 'there are more collisions'. Few indicated that a *higher proportion* (or higher percentage) of collisions have enough energy to produce a reaction. 'More collisions having enough energy to produce a reaction' is insufficient.

(e) Most candidates named the compound correctly. Errors included 'ammonia' or 'ammoniam' instead of ammonium and 'sulfide' or 'sulfite' instead of sulfate.

Question 4

(a) This equation was not done well, despite the formula of magnesium sulfate being provided. The most common error was the omission of hydrogen as a product or attempts such as '$Mg + SO_4 \rightarrow MgSO_4$'.

(b) Most candidates gave suitable answers here. Weaker responses described what would be seen *during* the reaction.

(c) It was apparent that candidates were unfamiliar with the terminology of simple procedures involved in salt preparation. 'Filtrate' was by far the most common response seen.

(d) (i) 'Saturated' was well known.

(ii) Only a very small minority of candidates linked the reduction in solubility to a decrease in temperature. Most talked about 'solidifying' or 'freezing (from a melt)' or just 'crystals forming'.

(e) (i) The terms 'hydrous' and 'anhydrous' were often seen instead of 'hydrated'.

(ii) Many candidates were able to calculate the M_r of $MgSO_4$ and used this to determine the number of moles of $MgSO_4$. A much smaller proportion understood how to calculate the moles of water involved in the formula and thus did not determine the value of *x*.

(f) Very few candidates knew the equation for the decomposition of $Mg(NO_3)_2$.

Question 5

(a) The general formula of alkanes was well known, but candidates need to be careful in the use of subscript. $C_nH_{2n}+2$ or C_nH2_{n+2} did not receive credit.

(b) Most candidates made the connection with light, but many omitted the ‘ultraviolet’ requirement.

(c) Most candidates correctly identified the type of reaction as substitution.

(d) Many candidates correctly identified hydrogen chloride as the other product of the reaction. Weaker responses stated ‘hydrochloric acid’. ‘HCl’ was not credited as a name was asked for, and HCl could be interpreted as hydrochloric acid.

(e) (i)(ii) These questions asked for the identity of two energy changes. ‘Activation energy’ was well known as the answer to **(i)**, but many identified the energy change in **(ii)** as ‘energy change’ rather than ‘energy change of reaction’. Weaker responses stated ‘endothermic’ and ‘exothermic’ respectively.

(iii) The question asked candidates to explain how the energy profile diagram shows the reaction was exothermic, but most candidates did not address the question and related the overall energy change to breaking and making of bonds with no reference to the diagram at all.

(f) In general, candidates were confident in performing the two calculations involving bond energies, and the answers 3050 kJ and 3170 kJ were frequently seen. However, a significant minority did not realise that the net energy change was found by subtracting 3170 from 3050 to give –120 kJ / mol. Doing the reverse subtraction to give +120 kJ / mol was a common error.

Question 6

(a) The general formula of carboxylic acids, $C_nH_{2n+1}COOH$, was well known, but candidates need to be careful in the use of subscript. $C_nH_{2n+}1COOH$ did not receive credit.

(b) The name, methanoic acid, was well known. Candidates should be aware that the correct spelling is important for organic chemicals. ‘Methenoic acid’ suggests the presence of an alkene group.

(c) Many candidates did not understand the definition of a molecular formula and gave the condensed structural formula HCOOH.

(d) The ability to convert the structure of methanoic acid into a dot-and-cross diagram was done well. Candidates should understand that a single bond is one dot / cross pair and double bonds are two dot / cross pairs. All the non-bonding electrons were frequently omitted.

(e) (i) The correct name, propyl methanoate, followed by a correct structure was frequently seen. However, ‘methyl propanoate’ occurred frequently as an incorrect answer.

(ii) Nearly all candidates knew that water was produced during ester formation.

(iii) Candidates who performed well were aware that methyl propanoate was an isomer of propyl methanoate. Ethyl ethanoate was another acceptable response as an example of an isomer of a four-carbon ester. Candidates only need to know the names of straight chained esters so attempts at branched esters including the use of numerals such as propyl 2-methanoate received no credit.

Butanoic acid was usually correctly identified as the four-carbon carboxylic acid.

CHEMISTRY

Paper 0620/43
Theory (Extended)

Key messages

- Formulae and equations, including ionic equations and ionic half-equations, were an area of weakness for many candidates.

General comments

The paper was generally well answered with only a few candidates gaining very few marks and some candidates gaining full marks.

Questions about practical work were answered the least well.
Many candidates gave names of chemicals formed when they were asked to describe observations.

Comments on specific questions

Question 1

(a) This was answered very well. A common error was to write 1 instead of +1 for the charge on a proton. A small number of candidates gave 1/1840 as the relative mass of a proton and/or a neutron.

(b) Candidates answered this extremely well. An occasional error was to identify the missing symbol as O instead of S.

Question 2

(a) (i) This was answered very well. H was an occasional wrong answer.

(ii) This was answered very well. E was an occasional wrong answer.

(iii) This was answered quite well. D and I were seen occasionally.

(b) This was answered very well. D was commonly correct. Conduction of electricity was given as the reason, although reference to the solid state was often omitted. F was seen occasionally due to the high melting point.

(c) This was answered very well. Some candidates identified H or G as macromolecular, presumably due to no conduction of electricity.

(d) This was answered less well than **(b)** and **(c)**. Those who identified I stated that it conducted electricity but often omitted to say *only* in the liquid state.

Question 3

(a) This was answered very well. Hematite and bauxite were seen very occasionally.

(b) A number of candidates learnt the syllabus definition of electrolysis perfectly. Those who attempted to explain electrolysis without using the syllabus definition, often missed out various key words or phrases. Separation was sometimes used instead of breakdown. The fact that compounds had to be ionic to undergo electrolysis was often missing.

(c) (i) Common errors included that cryolite:
- is a catalyst
- is an electrical conductor
- reduces the melting point of aluminium
- lowers the boiling point.

Cryolite is a solvent, however, this is merely repeating part of the question as opposed to giving an answer.

(ii) Ionic half-equations continue to be a problem for candidates. The usual errors of electrons on the right-hand side and 3A*l* on the right-hand side were again seen regularly. Some candidates suggested that electrons had three negative charges.

(iii) Many candidates achieved both marks. Carbon dioxide as a product was often omitted. Some candidates stated that the electrodes corroded/eroded/broke down/dissolved without reference to the chemical reaction that occurs.

(d) A correct answer required reference to an unreactive coating of aluminium oxide. The majority of answers omitted some or all of these items. Despite the introduction to the question, there was frequent reference to the reactivities of aluminium and copper that contradicted the opening statement.

(e) (i) This was answered quite well. Some candidates suggested that amphoteric meant a substance that reacted with *neither* acids or bases. Some seemed to confuse amphoteric with atmospheric.

(ii) This was answered completely correctly by a minority of candidates. AlO_2^- was often seen as a product instead of the sodium salt.

(f) Gallium(III) chloride was more likely to be seen than gallium(III) sulfate. Many did not know the formula of the sulfate ion; the sulfide ion was often used instead of the sulfate ion.

Question 4

(a) (i) This was answered quite well. The effect on equilibrium yield by decreasing the pressure was the part that caused the most difficulty.

(ii) This was answered quite well. Some candidates only referred to the position of equilibrium shifting to the right or an increase in yield without mentioning an endothermic reaction. Those who referred to an endothermic reaction often omitted to say that they were referring to the forward reaction. There are two reactions in any equilibrium. Some candidates made comments on the rate of reaction.

(b) This was answered extremely well. However, non-bonding electrons on the chlorine atoms were occasionally missing.

(c) Formulae were often incorrect. Those who put the formulae in the right places often omitted to balance the equation. Some candidates seemed unaware that an equation must be balanced.

(d) This was answered very well. Occasional errors included:
- using atomic numbers instead of relative atomic masses
- dividing all three percentages by the smallest percentage.

$P(OH)_3$ was seen occasionally as the answer.

(e) Answers other than formulae were common. Many worked out that the relative molecular mass of H_3PO_4 is equal to 98 but went no further.

Question 5

(a) (i) This was answered well. Some candidates gave a pressure of 200 atm and an iron catalyst, showing obvious confusion with the Haber process. Vanadium oxide (without the oxidation state) was a common error.

(ii) This was answered very well. A small number of candidates used $2SO_3$.

(iii) Only a minority of candidates answered this correctly. Sulfur dioxide, sulfur trioxide, oxygen, hydrogen and sulfuric acid were commonly seen.

(b) Candidates found this one of the most difficult questions on the paper. Many answers were neither black nor solids. The substances named often contained elements other than those present in sugar or sulfuric acid. Some answers (such as carbon hydroxide) were imaginary substances.

(c) (i) This calculation was done quite well. Some candidates showed multiplication by 24 000 to give a final answer of 30.

(ii) This calculation was done less well. Only a minority of candidates knew that if the mole ratio changed from 1 : 2 to 1 : 1 the volume of sulfuric acid would be doubled. Some candidates halved the volume instead of doubling it; others suggested that the volume would be unchanged.

(d) (i) The lilac flame colour was well known. Colours from other cations on the syllabus were seen occasionally.

(ii) Answers were often given as names rather than observations. Effervescence was a common correct answer. The disappearance of the solid and the formation of a blue solution were seen less often. Many candidates described a deep blue solution showing obvious confusion with the use of aqueous ammonia in the test for copper(II) ions. Unnecessary and sometimes incorrect tests for gases were seen.

(iii) This was correct in only a minority of cases. Effervescence was a common answer. The precipitate was sometimes described as cream coloured.

(e) Candidates appear to have difficulty with ionic equations in general. Candidates should learn that an ionic equation for precipitation involves an aqueous cation and an aqueous anion on the left-hand side and the solid precipitate on the right.

Question 6

(a) (i) This was answered quite well. The most common errors were missing out a bond or bonds and carrying out the subtraction the wrong way round.

(ii) This was done less well. Those candidates who referred to bond breaking and bond forming often made incorrect statements such as ‘energy given out when bonds are broken’ or ‘energy required to form bonds’. Some candidates referred to bonds being broken, or bonds being formed rather than both. Statements, such as ‘endothermic because energy is taken in from the surroundings’, were often not qualified with a reason.

(b) (i) This was answered very well. The most common incorrect answer was ‘one’.

(ii) Candidates should be aware that all alkenes with more than three carbon atoms have a number as part of their name. Butene was much more common than but-1-ene. The structure was often shown as a repeat unit complete with extension bonds but without a double bond. In some cases, the carbon atoms in the double bond had a valency other than 4. The ethyl group was often written without showing any bonds i.e. as C_2H_5.

(iii) This was often incorrect. C_4H_8 was a common answer as was $(CH_2)_n$.

(c) (i) Only a minority of candidates answered this correctly. Cracking was the most common answer. Digestion, decomposition, polymerisation and hydration were also regularly seen.

(ii) Only a minority of candidates answered this fully correctly. Enzyme was commonly seen. Acid was less common.

The question asked for *types* of substances as opposed to *names* of substances. Many candidates gave names of enzymes and/or names of acids.

(iii) Those candidates who were familiar with the processes involved in separation and identification of amino acids often performed well. However, many candidates seemed unfamiliar with the techniques involved and often did not gain credit. Fractional distillation and indicators were regularly mentioned.

The question asked for *type* of substance used to detect as opposed to *names* of substances. Weaker responses stated ninhydrin as the answer.

(d) (i) The majority of candidates gave nylon as the answer. Incorrect answers included terylene.

(ii) Only a minority of candidates gained credit here. Carboxylic acid was the most likely correct answer seen. Amide was often seen as opposed to amine. Alcohol and alkene were common incorrect answers.

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Paper 0620/51
Practical Test

There were too few candidates for a meaningful report to be produced.

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Paper 0620/52
Practical Test

Key messages

- Candidates should go through their plans when answering **Question 3** before writing their response. There is no need to list apparatus or variables at the start of the plan.
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then the mark will not be awarded.
- Candidates should be aware that the mark allocation reflects the number of valid points to be made for parts of questions.

General comments

Most candidates successfully completed all questions and there was no evidence that candidates were short of time. The complete range of marks was seen.

The paper discriminated successfully between candidates of different abilities but was accessible to all.

The majority of candidates were able to complete tables of results from readings on diagrams and then handle the data obtained as in **Question 2**.

Comments on specific questions

Question 1

(a) Most candidates correctly completed the tables of results. Many did not seem to understand what was required for 'temperature change since the start' and gave temperature changes from the previous reading. A number of candidates produced random numbers.

(b) The *y*-axis often had an incorrect scale and temperatures were plotted instead of temperature changes. Curves were often not smooth, and labels were missing.

(c) This was generally well answered. A small number misjudged where 13 cm^3 would be and read off the value for Experiment 2 instead of Experiment 1.

(d) Few candidates could explain that this was because the acid was in excess. 'Reaction had finished' was creditworthy. Vague references to solutions being used up were frequently seen.

(e) Many candidates did not deduce that solution **G** was more concentrated. The idea of changing concentrations was common.

(f) This was well answered. Most candidates knew that the polystyrene cup would be an insulator. A common misconception was that the polystyrene cup would react with the acid or melt.

(g) Vague answers referred to a burette being hard to use or not big enough.

Question 2

(a) Many candidates gained credit for effervescence but did not do the limewater test.

(b) The majority of candidates identified a red coloured flame correctly.

(c) Many candidates identified solid **I** as lithium carbonate.

(d) Many candidates reported the formation of a white precipitate. A significant number stated that the precipitate would be cream-yellow or white-cream and was insoluble.

(e) Candidates noted that the precipitate was insoluble.

(f) Many candidates incorrectly described a change.

(g) A white precipitate was often given.

(h) Solid **J** was often identified as calcium chloride.

Question 3

Candidates were asked to plan an investigation to compare two hydrogels.

The complete range of marks was seen in this planning question. The quality of responses was often centre dependent.

A large number of candidates did not give fully quantitative answers by not using a known or stated mass of hydrogel. A common error was not to mix the hydrogel with water or not stating how the unabsorbed water is removed from the hydrogel.

Suitable apparatus was required; this should be stated in the method and not in a list of apparatus since an item named in an apparatus list does not make it clear for what that apparatus was used.

A minority of candidates used the wrong method such as fractional distillation or chromatography. These methods showed a lack of knowledge and understanding.

A significant number of candidates did not attempt the question.

CHEMISTRY

Paper 0620/53
Practical Test

Key messages

- It is essential that centres make up solutions and provide apparatus in accordance with the details contained in the Confidential Instructions. If there is difficulty in obtaining some substances, then the centre should contact Cambridge for advice. Centres should submit a full set of Supervisor's results that have qualitative results for **Question 1** and the observations for each test in **Question 2**.

- Candidates should go through their plans when answering **Question 3** before writing their response. There is no need to list apparatus or variables at the start of the plan.

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

- Where, in a quantitative task, a reagent is added dropwise (or gradually) and then in excess, candidates should give two sets of observation for the dropwise addition and then for the addition in excess, making it clear which observation is for dropwise addition and which is for addition in excess.

- In qualitative analysis, where the question states 'test any gas produced', candidates should describe and give the result of any **positive** gas test they carried out.

- It is recommended that graph scales are chosen so that each major grid line is equivalent to 1, 2, or 5 (or those numbers multiplied by 10^n) – this is indicated in the mathematical requirements in the syllabus and by the Association for Science Education (A.S.E.). Data points should be plotted using a cross (X) or an encircled dot (⦿) and should not be obscured by the graph line, which should be drawn using a sharp pencil.

General comments

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

A wide variety of approaches was seen in **Question 3** (the planning exercise). Any approach which would yield appropriate quantitative results could gain full credit.

In **Question 1**, most centres obtained results that were in line with those expected given the concentrations of the solutions specified in the Confidential Instructions.

Comments on specific questions

Question 1

(a) The majority of candidates successfully completed all five experiments with increasing temperatures from Experiments 1 to 5. A small minority of candidates recorded temperatures to an inconsistent precision (number of decimal places) or recorded times that were not in seconds to the nearest whole number.

(b) The majority of candidates wrote a linear scale on the *y*-axis. Candidates who chose an awkward scale (such as each large square representing 15 or 30 seconds) often made errors when plotting the data from the experiments. The expected results should have given points lying on a smooth curve, although a ruler drawn straight line was acceptable if that fitted the data. Thick lines or wobbly lines that moved from point to point did not gain credit for drawing a best-fit line.

(c) Almost all candidates identified Experiment 5 as having the fastest rate. The most common error was to state Experiment 1 as having the fastest rate.

(d) Most candidates were able to successfully extrapolate their graph lines and read off the time at 60 °C. The most common errors were omission of the units (s), giving incorrect units (such as °C) or misreading the graph scale.

(e) This was a demanding question and answers suggested that many candidates were unfamiliar with conducting experiments over a range of temperatures. Many answers focused incorrectly on the cost of materials or the time-consuming nature of the experiment. Only a minority of candidates were able to state that it would be difficult to have identical temperatures for each repeat. The very best responses explained why this was difficult in terms of variable heat loss to the surroundings during the reaction.

(f) This was another demanding question. Better performing candidates were able to state that the solutions would be reacting while they were being heated or that the temperature would be increasing during the reaction.

(g) (i) The majority of candidates were able to correctly state that polystyrene is an insulator or poor thermal conductor. Stronger responses went on to say that this would result in the temperature of the reaction mixture remaining more constant.

(ii) A number of candidates thought that the potassium iodate would react with the polystyrene cup, despite having just completed the reaction with potassium iodate in a polystyrene cup. However, many candidates were able to correctly state that the polystyrene would melt or burn.

(h) Many correct graph lines were seen. Many candidates did not gain credit because they joined the sketched line to the line drawn in **(b)**. A small number of candidates ignored the instruction to sketch the line **on the grid** and instead drew another pair of axes in the space under **(h)**.

Question 2

(a) Most candidates gave either a correct observation from the reaction (such as effervescence) or the correct gas test and result. Only the better performing candidates gave both an observation and a positive gas test. Incorrect gas tests were often seen; the most common of which was 'blue litmus turning red' – which suggests the damp litmus paper was held to close to, or even in, the acid.

(b) (i) Many candidates correctly reported a white precipitate forming, but some did not then go on to say what happened when excess aqueous sodium hydroxide was added.

(ii) Many candidates correctly reported a white precipitate forming, but some did not then go on to say what happened when excess aqueous ammonia was added.

(c) Better performing candidates were able to fully identify solid **N**, although identifications which did not fully fit the observations in **(a)** and **(b)** were common.

(d) This is one of the more difficult flame test colours to see clearly as it is often transient or masked. Where a supervisor reported a colour other than lilac (normally the yellow from sodium ions), then that colour was accepted as a correct answer from the candidates. This cannot be done if the supervisors' results are not recorded.

(e) Most candidates correctly gave a strongly alkaline pH value, however, a number of candidates reported acidic pH values.

(f) As solution **O** was aqueous potassium hydroxide, there should have been no change when it was tested with nitric acid followed by a few drops of aqueous barium nitrate. The solubility of barium hydroxide is high enough for no precipitate to form if the concentrations and quantities used are as specified. Some candidates were not confident with the idea of negative tests and so impossible colour changes, effervescence or the formation of precipitates were seen.

(g) The majority of candidates correctly stated that a blue precipitate formed, however, some then did not go on to state that the precipitate remained when excess aqueous copper(II) sulfate was added.

(h) Many candidates were able to fully identify potassium hydroxide. Common errors included stating it was a sulfate (presumably because in **(f)** the test for sulfate ion was carried out) or that it was a copper(II) compound (presumably because of the blue precipitate in **(g)**).

Question 3

A wide variety of approaches to this planning task was seen; any approach that could produce appropriate quantitative results could gain full credit.

As this was a plan for a quantitative investigation, candidates needed to control the quantities of each reagent used. For the fizzy drink, as it was a liquid, a specified volume should be used and for the sodium hydrogencarbonate, as it was a solid, a specified mass (or an excess – depending on the method chosen) was required.

Suitable apparatus was required; this should be stated in the method and not in a list of apparatus, since an item named in an apparatus list does not make it clear for what that piece of apparatus was used. It should be noted that it is not possible to attach a gas syringe or delivery tube to a beaker.

Something needed to be measured at an appropriate point. This could have been, for example, the volume of gas made, or the mass of carbon dioxide lost either at the end of the reaction or after a specified time. It was expected that the final part of the answer would say how the quantitative result obtained would be used to determine which drink contained the greatest concentration of phosphoric acid.

Common errors were to use the term ‘amount’ rather than volume or mass, to omit stating when the measurement was made or to use inappropriate apparatus.

At the start of the plan, there is no need to list dependent and independent variables, produce a list of apparatus or list standard safety precautions.

CHEMISTRY

Paper 0620/61
Alternative to Practical

Key messages

- Readings taken from a given item of apparatus should all be recorded to the same resolution (the same number of decimal places).
- Where, in a quantitative task, a reagent is added dropwise (or gradually) and then in excess, candidates should give observations for the dropwise addition and then for the addition in excess; making it clear which observation is for dropwise addition and which is for addition in excess.
- When plotting graphs, points should be plotted as a cross (X) or an encircled dot (⊙) and not obscured by the graph line, which should be drawn using a sharp pencil. Lines of best fit should be smooth curves or ruler-drawn straight lines; they should not wobble from point to point.

General comments

The majority of candidates successfully attempted all of the questions. The paper discriminated successfully between candidates of different abilities but was accessible to all. The paper was generally well answered, with very few blank spaces. The most common questions to not be attempted were those where candidates had to add to an existing diagram or graph – this could suggest that some candidates looked for the answer lines rather than reading the whole paper carefully.

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

Comments on specific questions

Question 1

(a) This question was often left blank. As the question requires the addition of an arrow to the diagram, there is no answer line on which to write an answer. This lack of an answer line may have resulted in some candidates not realising there was a question to be answered. Most candidates who answered the question correctly indicated that there should be heat under the left-hand conical flask. The most common error was to heat the concentrated sulfuric acid in the right-hand conical flask.

(b) The majority of candidates could correctly name the conical flask shown in the diagram. A ‘triangular beaker’ is not an acceptable alternative name for a conical flask.

(c) Most candidates correctly identified the substance labelled **B**. However, some candidates were careless and gave the name incorrectly as ‘sodium sulfate’.

(d) Most candidates were able to use the information at the start of **Question 1** and state that a fume cupboard should be used because the gas made was toxic.

(e) Many candidates were able to identify one of the errors in the set-up of the apparatus. Some answers suggested a lack of familiarity with the preparation and collection of gases. The most common error was to state that the inverted gas jar should be covered or have a bung in it. However, if it was sealed the increase in pressure would result in the dilute hydrochloric acid being spayed out of the flask. Better performing candidates were able to state that the gas jar should not be inverted (as the gas being collected is denser than air) and that the glass tubes in the right-hand conical flask were the wrong length. The left-hand tube should be in the concentrated sulfuric acid and the right-hand tube should be above it.

Question 2

(a) The majority of candidates were able to correctly read the temperatures from the thermometer diagrams and calculate the mass of solid sodium sulfate remaining.

(b) Most candidates plotted the data on the grid. However, it was not uncommon for candidates to ignore the instruction to draw **two** curves of best fit; one of which should have gone through the first four points. It was common for the line to incorrectly pass through the first five points and so have a kink at the top of the line. Some graph lines were too thick or were multiple lines and so could not be credited.

(c) (i) Most candidates gained full credit. Some candidates did not show on the grid how they worked out their answer. The expectation was that candidates would draw a vertical line from 55 °C on the *x*-axis to the graph line they had drawn and from there, a horizontal line to the *y*-axis.

(ii) Better performing candidates gave fully correct answers to this calculation by dividing the answer from **(c)(i)** by the volume in dm^3 ($25 \div 1000$), some forgot the conversion factor of division by 1000.

(d) Many candidates were able to read from their graphs the two temperatures at which 11.0 g of solid would remain in the evaporating basin. Some candidates did not include the units for the temperature.

(e) In the details of the experiment, candidates were told a 25.0 cm^3 portion of the saturated solution was removed from the beaker. The most appropriate item of apparatus to do this is a volumetric pipette.

(f) (i) Better performing candidates realised that an excess of sodium sulfate was required so that the solution would be saturated. Common errors were to state ‘it speeded up the reaction’ or ‘it made sure all of the sodium sulfate was used up’.

(ii) Better performing candidates correctly stated that stirring caused the sodium sulfate to dissolve faster. Some candidates incorrectly thought that more would dissolve.

(g) This proved to be a very demanding question and only the strongest candidates could explain the idea of heating to constant mass. The most common incorrect method was to add anhydrous copper(II) sulfate or anhydrous cobalt(II) chloride and look for a colour change. Not only will this method not work (if a very small amount of water remains, then these chemical tests will not show a positive result), they will add a substance to the evaporating basin and so increase the mass of solid; it is the mass of solid remaining which is being determined.

(h) This was another very demanding question part. The experimental results showed that as the temperature increased, after around 33 °C, the mass of solid sodium sulfate left in the evaporating basing decreased. This shows that the solubility of sodium sulfate decreases as the temperature increases above around 33 °C. If a saturated solution at 80 °C is cooled, the solubility of the sodium sulfate increases and so no change is seen. The most common error was to state that a solid would form.

Question 3

(a) Many candidates correctly stated that a white precipitate would form, but some did not then go onto stating what would happen when excess aqueous ammonia is added.

(b) Many candidates realised that the test described was the test for sulfate ions. They deduced that as solid **W** did not contain sulfate ions, there would be no reaction. A common error was to state that a white precipitate would form – presumably as this is the positive result of the sulfate ion test.

(c) Better performing candidates realised that this was the halide ion test and that, as solid **W** was a bromide, a cream precipitate would form.

(d) (i) A significant number of correct answers were seen. Many candidates did not associate **test 1** with the test for sulfur dioxide gas. Incorrect gases such as carbon dioxide and hydrogen were often seen, as were substances that are not gases.

(ii) The chemical test for the presence of water was well known.

(e) Better performing candidates were able to identify solid **X** as iron(II) sulfate. Common errors were to omit the oxidation state of iron or to state the substance contained chloride ions (presumably because a halide ion test had been carried out), or chromium ions (probably due to the green precipitate formed in **test 4**).

Question 4

This was a straightforward planning task and candidates who read the question carefully were able to perform well. There were two stages to be addressed in the investigation. The first stage required the coloured substances to be extracted from the leaves. This can be achieved by grinding the leaves using a pestle and mortar, adding ethanol to the ground leaves and stirring prior to filtering in order to remove the undissolved solids. The second stage requires the extract from the leaves to be tested with an acid (such as hydrochloric acid) and an alkali (such as aqueous sodium hydroxide) and looking for colour changes.

A very common error (which was ignored during the marking, so candidates could still go onto gain full credit) was to conduct chromatography of the coloured substances in the leaves. Unfortunately, many candidates who described chromatography at length thought they had completed the plan and so did not then go on to test the compounds to see if the colour changed when tested with an acid and an alkali.

It should be noted that as this was a qualitative task (as opposed to a quantitative one), there was no need to use leaves of the same size and mass or to control the volume of solvent used.

CHEMISTRY

Paper 0620/62
Alternative to Practical

Key messages

- Candidates should go through their plans when answering **Question 4** before writing their response.
- There is no need to list apparatus or variables at the start of the plan.
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then credit will not be awarded.
- Candidates should be aware that the mark allocation reflects the number of valid points to be made for parts of questions.

General comments

Most candidates successfully completed all questions and there was no evidence that candidates were short of time. The complete range of marks was seen.

The paper discriminated successfully between candidates of different abilities but was accessible to all.

The majority of candidates were able to complete tables of results from readings on diagrams and then handle the data obtained as in **Question 2**.

Comments on specific questions

Question 1

(a) Credit was awarded for correctly naming the beaker. A small number of candidates were confused and named a burette or flask. A common error was to think that the label pointed to the chromatography paper.

(b) Most candidates gained partial credit. The solvent level was often drawn above the baseline.

(c) Most candidates correctly named a dropper or (teat) pipette. Incorrect answers using burettes or syringes were prevalent.

(d) A significant number of candidates described the colour spreading or the solvent reaching the baseline.

(e) Chromatography was generally well known.

Question 2

(a) Most candidates correctly completed the tables of results from the thermometer diagrams. The commonest error was to round all values to whole numbers. Many candidates did not seem to have understood what was wanted for ‘temperature change since the start’ and gave temperature changes from the previous reading. A number of candidates produced random numbers.

(b) The *y*-axis was often an incorrect scale and temperatures were plotted instead of temperature changes. Curves were often not smooth, and labels were missing.

(c) This was generally well answered. A small number misjudged where 13 cm^3 would be and read off the value for Experiment 2 instead of Experiment 1.

(d) Few candidates could explain that this was because the acid was in excess. ‘Reaction had finished’ was creditworthy. Vague references to solutions being used up were frequent.

(e) Many candidates did not deduce that solution **G** was more concentrated. The idea of changing concentrations was common.

(f) This was well answered. Most candidates knew that the polystyrene cup would be an insulator. A common misconception was that the polystyrene cup would react with the acid or melt.

(g) Vague answers referred to a burette being hard to use or not big enough.

Question 3

(a) Many candidates gained credit for identifying carbon dioxide.

(b) The majority of candidates correctly identified a carbonate.

(c) Many candidates reported the formation of a white precipitate. A significant number stated that the precipitate would be cream-yellow or white-cream and was insoluble.

(d) Candidates knew that the precipitate would be insoluble.

(e) Many candidates incorrectly described a change.

(f) A white precipitate was often given.

Question 4

Candidates were asked to plan an investigation to compare two hydrogels.

The complete range of marks was seen in this planning question. The quality of responses was often centre dependent.

A large number of candidates did not give fully quantitative answers by not using a known or stated mass of hydrogel. A common error was not to mix the hydrogel with water or not stating how the unabsorbed water is removed from the hydrogel.

Suitable apparatus was required; this should be stated in the method and not in a list of apparatus since an item named in an apparatus list does not make it clear for what that apparatus was used.

A minority of candidates used the wrong method such as fractional distillation or chromatography. These methods showed a lack of knowledge and understanding.

A significant number of candidates did not attempt the question at all.

CHEMISTRY

Paper 0620/63
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.

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

- The term 'amount' is not the same as volume or mass. When describing quantities, in **Question 4** for example, mass or volume should be used rather than amount.

General comments

Most candidates successfully attempted all the questions and the full range of marks was seen. The paper was generally well answered, with very few blank spaces.

The paper discriminated successfully between candidates of different abilities but was accessible to all. All questions discriminated equally well, although some were more demanding than others.

The majority of candidates were able to complete tables of results from thermometer and stop-clock diagrams in **Question 2**. The graph was also well drawn with nearly all candidates choosing a suitable scale.

A wide variety of approaches was seen in **Question 4**, the planning exercise, and any approach which would yield appropriate quantitative results could gain full credit.

Comments on specific questions

Question 1

(a) The vast majority of candidates successfully identified the conical flask and test-tube from the diagram.

(b) This was a novel question, but nevertheless produced excellent answers from many candidates who realised that the cotton had to be released so that the test-tube tipped over, allowing the reaction to take place. The most common correct answer was 'pull the cotton to release the test-tube'. Tilting or shaking the flask were also acceptable.

(c) Most candidates missed the fact that hydrogen chloride was a colourless gas and therefore it would not be possible to measure its volume in a measuring cylinder. Many also missed the fact that it was denser than air and so *could* be collected by downward delivery.

(d) A number of candidates made no attempt at completing this diagram. Most of those who did, correctly drew a syringe.

(e) (i) A minority of candidates knew that a fume cupboard was necessary when dealing with a toxic gas. A well-ventilated space was also accepted as an answer. Most mentioned masks, which would give little protection against a toxic gas.

(ii) Nearly everyone knew that gloves should be worn when handling a corrosive liquid.

Question 2

(a) The majority of candidates successfully read the time on all five stop-clock diagrams correctly, giving their answers in seconds. Most could also read the temperatures on the thermometer diagrams correctly, but many did not give them to a consistent precision (number of decimal places). Thermometers should be read to the nearest half degree e.g. to .0 or .5 °C.

(b) The majority of candidates wrote a linear scale on the *y*-axis, using 20 seconds to each large square. However, a few candidates chose an awkward scale (such as each large square representing 25 or 30 seconds) and, as a result, often made errors when plotting the data from the experiments. The results gave points lying on a smooth curve. Thick lines or wobbly lines that moved from point to point did not gain credit for drawing the best-fit line.

(c) Almost all candidates identified Experiment 5 as having the fastest rate. The most common error was to state Experiment 1 as having the fastest rate.

(d) Most candidates were able to successfully extrapolate their graph lines and read off the time at 60 °C. The most common error was omission of the units (s).

(e) This was a demanding question and answers suggested that many candidates were unfamiliar with conducting experiments over a range of temperatures. Many answers focused incorrectly on the cost of materials or the time-consuming nature of the experiment. Only a minority of candidates were able to state that it would be difficult to have identical temperatures for each repeat. The very best responses explained why this was difficult in terms of variable heat loss to the surroundings during the reaction.

(f) This was another demanding question. Better performing candidates were able to state that the solutions would be reacting while they were being heated or that the temperature would be increasing during the reaction.

(g) (i) The majority of candidates were able to correctly state that polystyrene is an insulator or poor thermal conductor. Stronger responses went on to say that this would result in the temperature of the reaction mixture remaining more constant.

(ii) A number of candidates thought that the potassium iodate would react with the polystyrene cup. However, many candidates were able to correctly state that the polystyrene would melt or burn.

(h) Many correct graph lines were seen. Many candidates did not gain credit because they joined the sketched line to the line drawn in **(b)**.

Question 3

(a) Most candidates gave either a correct observation from the reaction (such as effervescence) or the correct gas test and result; only better performing candidates gave both.

(b) Most candidates performed well.

(c) Many obtained full credit, although this was fewer than in **(b)**.

(d) Most candidates correctly gave a strongly alkaline pH. A number of candidates gave weakly alkaline or even acidic pH values.

(e) Many candidates were able to fully identify potassium hydroxide. Common errors included stating it was a chloride (presumably because **test 3** used aqueous silver nitrate) or a sulfate.

Question 4

A wide variety of approaches to this planning task was seen; any approach that could produce appropriate quantitative results could gain full credit.

As this was a plan for a quantitative investigation, candidates needed to control the quantities of each reagent used. For the fizzy drink, as it was a liquid, a specified volume should be used and for the sodium hydrogencarbonate, as it was a solid, a specified mass (or an excess – depending on the method chosen) was required.

Suitable apparatus was required; this should be stated in the method and not in a list of apparatus, since an item named in an apparatus list does not make it clear for what that piece of apparatus was used. It should be noted that it is not possible to attach a gas syringe or delivery tube to a beaker.

Something needed to be measured at an appropriate point. This could have been, for example, the volume of gas made, or the mass of carbon dioxide lost either at the end of the reaction or after a specified time. It was expected that the final part of the answer would say how the quantitative result obtained would be used to determine which drink contained the greatest concentration of phosphoric acid.

Common errors were to use the term ‘amount’ rather than volume or mass, to omit stating when the measurement was made or to use inappropriate apparatus.

At the start of the plan, there is no need to list dependent and independent variables, produce a list of apparatus or list standard safety precautions.