CHEMISTRY

Paper 0620/11
Multiple Choice (Core)

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

General comments

Question 2 proved to be particularly straightforward for candidates.

Candidates found **Questions 26**, **27**, **36** and **37** the most challenging.

Questions 4, **36** and **37** all had an approximately equal number of candidates choosing each alternative suggesting that a high proportion of candidates were guessing the answers.

Comments on specific questions

Question 3 – Response B

Candidates knew that impurities depressed freezing point but assumed that the same happened to boiling point.

Question 20 – Response C

Candidates knew the flame colour produced by sodium ions but did not know the test for sulphite ions.

Question 22 – Response C

Candidates clearly knew the reactivity trend in Group I but were unsure about the trend in Group VII.

Question 24 – Response B

The inertness of noble gases was not well understood.

Question 26 – Responses A and C

Many candidates thought that, in each of the columns, “no” suggested that the metal was unreactive.

Question 27 – Response A

Candidates did not know about the production of slag (reaction of calcium oxide with acidic impurities) and many mistook carbon dioxide for carbon monoxide.

Question 32 – Response B

Very few candidates knew about fermentation and many other candidates read *lime* as *limestone*.

Question 33 – Response B

Candidates did not appear to recognise that slaked lime is not used as a fertiliser.

CHEMISTRY

Paper 0620/12
Multiple Choice (Core)

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

General comments

Question 1 proved to be straightforward for candidates.

Questions 2, **7**, **26**, **35** and **39** proved to be more challenging for many candidates.

Questions 7, **10**, **12**, **27** and **39** all had an approximately equal number of candidates choosing each alternative suggesting that a high proportion of candidates may have been guessing the answers.

Comments on specific questions

Question 3 – Response A

A significant number of candidates incorrectly thought that both the melting and boiling points increase.

Question 5 – Response B

A common error was made about groups and periods in the Periodic Table and the link between these and the numbers of electrons and shells.

Question 6 – Response B

Many candidates ignored the additional electrons around hydrogen.

Question 13 – Response B

The word "heated" led many candidates to choose the response "exothermic" instead of concentrating on the nature of chemical change.

Question 18 – Response C

Some candidates perhaps choose the acidic phosphorus oxide because of the word "acidic" in the question.

Question 22 – Response C

Candidates clearly knew the reactivity trend in Group I but were unsure about the trend in Group VII.

Question 24 – Response B

The inertness of noble gases was not well understood.

Question 26 – Response A

Many candidates did not realise that copper does not react with dilute hydrochloric acid.

Question 32 – Response B

Very few candidates knew about fermentation and many other candidates read *lime* as *limestone*.

Question 35 – Response A

The operation of a fractionating column was poorly understood. Very few candidates knew that petroleum is not burned but evaporated.

CHEMISTRY

Paper 0620/13
Multiple Choice (Core)

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

General comments

Questions 1, 2, 4, 9 and **13** proved to be particularly straightforward for candidates.

Candidates found **Questions 14**, **15**, **30**, **32**, **35**, **38** and **40** the most challenging.

Questions 14 and **30** all had an approximately equal number of candidates choosing each alternative suggesting that a high proportion of candidates were guessing the answer.

Comments on specific questions

Question 5 – Response C

Some candidates did not read the definitions carefully.

Question 10 – Response C

Very few candidates knew the products of electrolysis for concentrated aqueous sodium chloride.

Question 11 – Response A

Many candidates did not read the question properly, missing the word “hydrocarbons”.

Question 15 – Response B

Many candidates possibly read the heading of the third column as *size*, not *surface area*.

Question 16 – Response C

Some candidates confused oxidation and reduction.

Question 18 – Response A

Many candidates knew that lime contains calcium but did not understand neutralisation.

Question 22 – Response C

Candidates clearly knew the reactivity trend in Group I but were unsure about the trend in Group VII.

Question 24 – Response B

The inertness of noble gases was not well understood.

Question 31 – Response D

Most candidates knew that the gas produced was ammonia but not how it was formed.

Question 32 – Response B

Very few candidates knew about fermentation and many other candidates read *lime* as *limestone*.

CHEMISTRY

Paper 0620/21
Multiple Choice (Extended)

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

General comments

Questions 1, **4**, **7**, **14**, **31** and **37** proved to be particularly straightforward for candidates.

Candidates found **Question 6** the most challenging.

Comments on specific questions

Question 10 – Response C

Many candidates chose the two most reactive metals rather than the two furthest apart in reactivity.

Question 12 – Response A

Candidates perhaps did not read the second statement carefully enough and focused on the phrase “heat is taken in”.

Question 15 – Response B

Many candidates possibly read the heading of the third column as *size*, not *surface area*.

Question 20 – Response B

Many candidates did not recognise that barium carbonate is an insoluble salt, even though it was stated in the question.

Question 21 – Response C

Candidates knew the flame colour produced by sodium ions but did not know the test for sulphite ions.

Question 23 – Response B

Most candidates seemed not to recognise that tin and lead are metals.

Question 24 – Response B

The inertness of noble gases was not well understood.

Question 33 – Response B

Many candidates did not realising that copper is below hydrogen in the reactivity series.

Question 34 – Response D

Candidates did not appear to recognise that slaked lime is not used as a fertiliser.

Question 40 – Response D

Most candidates realised that this question had something to do with polymers.

CHEMISTRY

Paper 0620/22
Multiple Choice (Extended)

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

General comments

Questions 1, **3**, **7**, **16**, **23**, **26**, **30** and **37** proved to be particularly straightforward for candidates.

Candidates found **Question 35** the most challenging.

Question 4 had an approximately equal number of candidates choosing each alternative suggesting that a high proportion of candidates were guessing the answer.

Comments on specific questions

Question 2 – Response A

A significant number of candidates incorrectly thought that both the melting and boiling points increase.

Question 12 – Response A

Candidates perhaps did not read the second statement carefully enough and focused on the phrase “heat is taken in”.

Question 15 – Response B

Many candidates possibly read the heading of the third column as *size*, not *surface area*.

Question 21 – Response B

Some candidates did not realise that barium formed a white precipitate and also did not take the second column into consideration.

Question 24 – Response B

The inertness of noble gases was not well understood.

Question 33 – Response B

Many candidates did not realising that copper is below hydrogen in the reactivity series.

Question 35 – Response A

The operation of a fractionating column was poorly understood. Very few candidates knew that petroleum is not burned but evaporated.

CHEMISTRY

Paper 0620/23
Multiple Choice (Extended)

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

General comments

Questions 1, **2**, **5**, **7**, **14**, **25**, **26**, and **30** proved to be particularly straightforward for candidates.

Candidates found **Question 9** the most challenging.

Question 9 had an approximately equal number of candidates choosing each alternative suggesting that a high proportion of candidates were guessing the answer.

Comments on specific questions

Question 10 – Response C

Many candidates chose the two most reactive metals rather than the two furthest apart in reactivity.

Question 11 – Response A

Many candidates did not read the question properly, missing the word “hydrocarbons”.

Question 15 – Response B

Many candidates possibly read the heading of the third column as *size*, not *surface area*.

Question 16 – Response A

Many candidates did not realise that, because the number of molecules of gas increases in the forward reaction, the equilibrium is favoured by low pressure.

Question 22 – Response C

Candidates clearly knew the reactivity trend in Group I but were unsure about the trend in Group VII.

Question 24 – Response B

The inertness of noble gases was not well understood.

Question 31 – Response C

The wrong catalyst was frequently selected.

Question 33 – Response B

Many candidates did not realising that copper is below hydrogen in the reactivity series.

Question 38 – Response C

Some candidates perhaps did not realise that hydration of ethene is a rapid reaction.

Question 39 – Response C

Many candidates got the acid and alcohol the wrong way round.

CHEMISTRY

Paper 0620/31
Theory (Core)

Key messages

- Candidates would benefit from more practice in answering questions relating to practical procedures, including tests for specific ions.
- Candidates should be reminded to use the correct chemical terminology when answering questions involving structure, bonding, rates of reaction and the particulate nature of gases.
- Candidates should ensure they read all of the questions carefully and make use of the Periodic Table, where appropriate.
- Candidates should clearly distinguish between rate and time taken in questions involving the effect of concentration on rate of reaction.

General comments

Many candidates answered this Question Paper well, showing a good knowledge of chemistry. The standard of English was generally good. Some of the questions were left unanswered by a minority of candidates. Questions commonly omitted included **Question 2(a)(iv)** (simple calculation), **Question 2(b)** (test for sodium ions), **Question 4(c)** (test for iodide ions) and **Question 7(d)** (separation of carbon from a mixture of carbon and magnesium).

Candidates need more practice in distinguishing between molecular, ionic and giant structures and understanding the difference between the arrangement and the proximity of particles.

Some candidates would have produced more accurate answers with more careful selection of relevant information from tables of data.

Many candidates need more practice in memorising simple chemical tests, e.g. the flame test for sodium and the silver nitrate test for halides.

Most candidates need further practice with questions requiring extended answers, in particular, the inclusion and organisation of specific details (which could be in bullet point form). Some candidates need further practice in using the Periodic Table to answer questions about atomic structure.

Many candidates were able to balance symbol equations and calculate relative formula mass. Other candidates need practice in using the equations given to answer questions about particular reactions. Some candidates also need more practice in calculating relative formula masses and in undertaking calculations involving simple proportions.

Comments on specific questions

Question 1

(a) (i) Nearly all candidates were able to identify a noble gas electronic structure.

(ii) This was almost always correct. A few candidates incorrectly suggested that **D** had 15 protons.

(iii) Most candidates identified the correct electronic structure. A few candidates chose **D**, focusing on the 4 outer electrons rather than the 4 shells.

(iv) Most candidates identified the fluorine atom. **C** or **D** were the most common incorrect answers.

(v) This was the least well answered part of the question and only the better-performing candidates identified the atom of a metallic element. Weaker responses did not demonstrate an understanding that most metallic elements are on the left-hand side of the Periodic Table so have 1, 2 or 3 electrons in their outer shells. The most common incorrect answers were **A** or **D**.

(b) Many candidates calculated the correct number of neutrons in chlorine but few candidates took note of the negative charge on the bromide ion. Many candidates therefore gave the incorrect answer of 35 electrons. Many candidates also worked out the correct number of protons in the two species. Other candidates either wrote down the mass number instead of the atomic number or wrote down the number of neutrons in the last column of the table. A few candidates added the mass number to the atomic number.

Question 2

(a) (i) Many candidates chose sodium. The most common error was to suggest silicate through not reading the word "positive" in the stem of the question.

(ii) Very few candidates gave the correct name for the SO_3^{2-} ion. Common errors included sulfate, sulfur trioxide, sulfur oxide or invented names such as sulfur oxygen. A few candidates suggested sodium oxide, thinking that "S" was the symbol for sodium.

(iii) Many candidates calculated the mass of silicate ions correctly. Other candidates did not use simple proportions correctly. A common error was to divide 12 by 250 to get an incorrect answer of 0.048 g. Other candidates used the value for sodium (11 mg) to get an answer of 2.75 g.

(iv) A minority of candidates were able to calculate the mass of solid formed by simple addition of the component masses. Other candidates seemed to think that all the salts were evaporated as well and gave the answer "0". Some candidates went a step too far and divided 1000 by 36.3 to obtain a value of 27.5 g. Other candidates added the masses of just the positive ions or just the negative ions.

(v) A minority of candidates identified calcium hydrogencarbonate. The most common error was to copy the name of the hydrogencarbonate ion incorrectly as "hydrocarbonate". Other common incorrect answers included calcium carbonate or calcium hydroxide. Some candidates disadvantaged themselves by not naming the calcium ion.

(b) A few candidates realised that a flame test is used for identifying Group I metal ions. Of those candidates who suggested a flame test, many gave an incorrect colour such as violet or red. A majority of the candidates suggested incorrect reagents such as sodium hydroxide, silver nitrate or litmus paper.

(c) Many candidates gave the correct formula of magnesium chloride. Other candidates did not appear to refer to the Periodic Table to find the relationship between group number and formula and so formulae, such as $MgCl_6$ and Mg_7Cl_2, were given. The error seen most frequently was to suggest $MgCl$.

(d) Many candidates realised that calcium was produced at the anode and chlorine at the cathode. The most common error was to give "chloride" as a cathode product. Some candidates reversed the anode and cathode products. Other candidates suggested incorrect products such as hydrogen (thinking that it was a solution that was being electrolysed) or magnesium.

Question 3

(a) Many candidates answered this fully correctly. Most candidates gained credit for the motion of the particles in the three structures. Fewer candidates recognised the type of bonding present, with the common suggestion that **Y** was covalent and **Z** metallic. A significant number of candidates focused on the strength of the bonding rather than the type of bonding. Many candidates did not understand the meaning of the term *arrangement* and wrote about the proximity of the particles instead.

(b) A minority of the candidates realised that with a greater pressure, the volume decreases. Many candidates only wrote about particles and did not consider what happened to the volume. Other candidates thought that the volume increased or that the plunger or the blocked end came out. A considerable proportion of those candidates who suggested that the particles were pushed closer together thought that the volume increased. Other common errors suggested were referring to increases in temperature or concentration or references to the particles themselves being compressed.

(c) A majority of the candidates gave a correct use of diamond. Common errors included cutlery, tools or equipment, which were all too vague; restating types of jewellery, which was included in the stem of the question; or giving lubricant or electrode, which confused diamond with graphite.

(d) Most candidates gained at least partial credit for selecting **A** and **C**. Other candidates gave one of these, often selecting **D** as a physical change. Few candidates gained full credit for the explanation, either because they wrote “it can be reversed” without any qualification, or because they did not refer to the fact that “no new substance is formed”.

Question 4

(a) Many candidates did not give a precise enough definition of diatomic, often just referring to “two atoms” instead of implying that they were in the same molecule. Many candidates suggested that diatomic meant that there were two types of atom in an element. Many candidates also seemed to think that the term diatomic refers to elements only.

(b) (i) A minority of candidates correctly referred to the relative reactivity of chlorine and bromine. The most common error was to relate the reactivity to reaction with potassium. Other errors included comparison of the reactivity of chloride and bromide instead of the elements or statements referring only to one element, e.g. “chlorine is very reactive”.

(ii) Only the better-performing candidates knew the colours of the halogens. Many candidates seemed not to realise that they should use the information in the equation to help them identify the species to focus on. The most common errors were to suggest that bromine is blue, green or white or that there is no colour change in the reaction.

(iii) Many candidates were able to balance the equation. Where the correct species were selected, full credit was often awarded. Common errors were to write species such as $KBrI$, $ClBr$ or KBr_2. Iodine was often written $2I$ rather than I_2. A significant minority of candidates repeated the reactants as the products.

(c) Very few candidates knew the test for iodide ions. It was common to see the starch test for iodine instead. Other incorrect tests included flame tests, electrolysis and the use of litmus. Of those candidates who gave the correct test reagent as silver nitrate, many suggested an incorrect colour for the precipitate formed. White was the most common incorrect colour given.

(d) (i) Most candidates selected a suitable use of chlorine. The most common error was to refer to a use in making plastics. This was not accepted since the word polymer was in the stem of the question. Other frequently seen answers were too vague, e.g. “in water” or “for making chemicals”.

(ii) Many candidates could explain the term *thermal decomposition*. A considerable number of candidates described only the word “thermal” or only the word “decomposition”. A few candidates disadvantaged themselves by writing about oxygen being used in the breakdown of the substance, which is a contradiction.

(iii) Few candidates gave two correct pollution problems caused by non-biodegradable plastics. The main error was to describe what biodegradable means rather than a pollution problem. There were many vague references to global warming, the ozone layer or acid rain. Many candidates referred to killing animals but few candidates qualified this by mentioning that the animals choke or get trapped.

Question 5

(a) Some candidates identified the OH group but many included the adjoining CH_2 group. A wide variety of incorrect combinations of atoms was seen, the most common being $CH_3C{=}C$. A minority of candidates circled individual carbon or hydrogen atoms.

(b) Many candidates did not count the number of hydrogen atoms correctly. The most common errors were 19 (through not including the OH hydrogen), 17 (through not including one of the CH_3 groups) and 4.

(c) A majority of the candidates recognised the C=C group as being responsible for unsaturation. The most frequently seen incorrect answers were either “no double bond” or “has a covalent bond”.

(d) (i) Many candidates described the trend correctly. Those not gaining credit either did not refer to the number of carbon atoms or suggested that the density decreases when the number of carbon atoms decreases.

(ii) Most candidates gave a suitable prediction. Those candidates who did not, often either gave predictions which were very different from the expected answer, e.g. –150 °C, or did not put a negative sign in front of the number given.

(iii) Very few candidates suggested that there was no trend. Most candidates either suggested that the melting point is zero (through the mistaken reference to the fact that the boiling point is 0 °C) or made a comment about the large difference between the melting points of propane and pentane.

(iv) Most candidates realised that pentane is a liquid at 30 °C. Fewer candidates gave a reason for this in terms of mentioning both the melting point and the boiling point. Many candidates quoted the values of these two fixed points but made no reference to 30 °C. Other candidates gave vague statements such as “it hasn’t boiled yet” or “it’s reached the melting point but hasn’t reached the boiling point”.

(v) Some candidates gave a good definition of the term *hydrocarbon*. Other candidates did not gain full credit because they omitted the essential word “only”. Many candidates did not gain credit because of imprecise or incorrect use of chemical terms. Statements suggesting that hydrocarbons are elements, atoms or mixtures of carbon and hydrogen could not be credited.

(vi) Many candidates drew the correct structure of ethane. Some candidates drew the structures of either ethene or methane.

(vii) Some candidates balanced the equation correctly. Other candidates balanced the carbon dioxide correctly but not the oxygen. Common errors in balancing the oxygen were $2O_2$ and $7O_2$. A few candidates wrote letters instead of figures in the spaces.

Question 6

(a) (i) Many candidates chose the incorrect metal. Iron was the most frequently seen incorrect answer but many candidates chose lead or silver instead of aluminium. The importance of low density was often ignored. Many candidates referred to cost.

(ii) Most candidates gave a suitable reason for the use of iron rather than tungsten. Incorrect answers often referred to melting point.

(iii) Many candidates chose tungsten, although a correct reason was not always given. The most common error was to suggest high strength.

(b) Some candidates wrote about general metallic properties rather than the properties specific to the transition elements. Common errors included: the metals are coloured; malleable; conduct electricity badly; catalytic activity. Some candidates mentioned specific chemical properties, including reaction with water or chlorine.

(c) Many candidates were able to balance the equation. The most common error was to try to balance the equation with 3W and $2O_2$. Some candidates put letters instead of figures in the spaces provided, often WO_2 on the right-hand side instead of $3O_2$.

(d) Most candidates gained at least partial credit and many candidates deduced the correct order of reactivity from the data provided.

(e) (i) Many candidates disadvantaged themselves by referring to time rather than rate. Other candidates suggested that rate decreases as concentration increases. This may also reflect the misconception that rate is equivalent to the time taken.

(ii) The most common error was to suggest that ethanoic acid reacts most rapidly. This reflected the misconception seen in **(e)(i)** that rate is equivalent to the time taken.

(iii) Some candidates used the information in the table to deduce a suitable value for the time taken to decrease the mass by 1 g. Most candidates' incorrect values were significantly different, e.g. 3 hours or 1000 hours.

(iv) Most candidates selected the correct pH. Although the most frequently seen error was to suggest pH 7, pH 10 and pH 13 were often selected.

Question 7

(a) Many candidates gave a suitable explanation of the energy level diagram. The most common errors were to suggest that bond breaking occurred or to give descriptions of carbon dioxide being formed without mentioning a release of energy or heat.

(b) The origin and effects of the atmospheric pollutants were not always well known. The most frequently seen reason for not gaining credit was through imprecise statements about combustion of fossil fuels. Many candidates did not mention that carbon monoxide is formed through incomplete combustion of fossil fuels. Other answers just mentioned burning, which was insufficient.

The effects of carbon dioxide and methane on the environment were not well known. There were many incorrect statements about acid rain and the ozone layer. Many candidates did not gain credit for the effect of methane on health because they did not focus on the word "health" and gave general effects on the environment such as global warming instead. Those candidates who did focus on health often incorrectly gave extended descriptions of the blood and oxygen carriage, rather than the simple idea that carbon monoxide is toxic.

(c) (i) Few candidates gave a suitable use for calcium oxide. The most common error was to suggest that it is used in the blast furnace for the extraction of iron. Those who stated that it is used in the manufacture of steel, however, did gain credit. Other errors included: making limestone; neutralising acids (too vague); in buildings (too vague); cooking food (confusion of lime with the fruit). Many candidates gave answers which referred to properties rather than a use, e.g. "it is a basic oxide".

(ii) Some candidates calculated the molar mass of calcium carbonate correctly. Other candidates tried to do mole calculations. The most common errors were to ignore the fact that there are three oxygen atoms in calcium carbonate or to give the answer 124 obtained by a misunderstanding of the formula, this figure being obtained by $40 + ((16 + 12) \times 3)$.

(d) Only the better-performing candidates gained full credit here with many candidates only giving the addition of hydrochloric acid to the mixture correctly in their answer. Many candidates did not gain any credit because they added hydrochloric acid to magnesium and carbon separately, rather than to the mixture. Few candidates mentioned how they would wash or dry the carbon. Many candidates provided further steps before the filtration of carbon, the most common being to add water to the mixture of hydrochloric acid, carbon and magnesium chloride. Other candidates suggested that the magnesium chloride was a solid which would remain on the filter paper with the carbon.

CHEMISTRY

Paper 0620/32
Theory (Core)

Key Messages

- Questions requiring simple answers, for example about atomic theory, were usually answered well. Questions on more detailed aspects of kinetic particle theory would have benefitted from more focused explanations and attention to detail.
- Some candidates need more practice in answering questions requiring extended responses, such as **Questions 3(a)** and **7(d)**. The mark allocation is an indication of the number of relevant points that candidates should make.
- It is very important that candidates read the questions carefully in order to understand what exactly is being asked. Practice in reading and interpreting data-based questions should be prioritised.
- Many candidates need more practice in answering questions involving practical techniques, in particular specific revision of the chemical tests.

General Comments

Many candidates tackled this paper well, showing a good knowledge of chemistry. Balancing and completion of chemical equations was done extremely well.

Candidates should be aware of the difference between the words for halogens, e.g. “bromine”, and the words for the halide ions, e.g. “bromide”; the terms are not synonymous and should not be used interchangeably. Candidates should also be aware of the difference between the rate of reaction and the time taken.

For questions such as **Question 4(b)(ii)** the quality of diagrams produced by candidates was very poor. Candidates should be encouraged to practise drawing and labelling experimental apparatus. Candidates’ knowledge of chemical tests was also poor, such as was required for **Question 2(b)** and **Question 3(c)**.

Some candidates found it difficult to use data to support their answers in questions such as **Question 6(a)**. For the less structured questions, some candidates wrote their answers as short phases or bullet points, which meant that they were less likely to write vague statements or contradict themselves.

Comments on Specific Questions

Question 1

(a) (i) Most candidates answered this question correctly. The most common wrong answer was **E**.

(ii) This question was answered very well and very few wrong answers were seen.

(iii) This question was answered well.

(iv) This question was answered poorly. Many different incorrect answers were suggested.

(v) This question was not answered well.

(b) Only a very small number of candidates deduced the correct number of electrons in an oxide ion with 8 given as a common incorrect answer. The number of protons in both species was often confused with the number of nucleons.

Question 2

(a) (i) Only a very small minority of candidates got this answer correct with “chlorine” being the most common incorrect answer.

(ii) Most candidates answered this question correctly.

(iii) Many candidates found this calculation question challenging.

(iv) Many candidates found this calculation question challenging.

(v) Common incorrect answers to this question were “sodium hydrocarbonate” and “sodium carbonate”.

(b) Very few candidates scored full credit for this question. Many incorrect chemical tests were seen, such as the silver nitrate test to identify halide ions.

(c) This question was very well done by most candidates. Some candidates included the ionic charges in the chemical formulae of the compounds while other candidates did not give the numbers in the formulae as subscripts.

(d) Many candidates achieved full credit for this question. Some candidates inverted the two products. There was also some confusion regarding the difference between “bromide” and “bromine”.

Question 3

(a) Many candidates misinterpreted the instruction to describe *bonding* and just stated that the three different substances were “solid, liquid and gas” respectively, instead of the type of bonding present being “ionic, covalent and covalent” respectively.

Many candidates did not give the instruction to describe *arrangement* and *motion* enough thought. “Regular and random” are good describing words for arrangement, whereas “vibrate, sliding and rapidly” are good descriptive words for motion.

(b) Many candidates did not comment on how the volume would change and some candidates thought that because the pressure remained constant, the volume would too. Many candidates wrote about the particles gaining energy and moving more instead of linking their answer to the gas volume.

(c) A “colour change” means that the start colour and end colour must be recorded. In many cases candidates gave one colour only.

(d) Very few correct answers were seen for this question.

Question 4

(a) (i) Only the better-performing candidates got this question correct. Common incorrect answers were “aluminium oxide” or “alumina”.

(ii) This question was not answered correctly by many candidates with many candidates suggesting that “aluminium would react with the carbon” which showed a distinct lack of understanding. Many candidates did not realise that the answer related to reactivity.

(b) (i) This question was answered well by most candidates.

(ii) This question was poorly answered. Many candidates did realise that a gas syringe was needed and drew one but the connection to the conical flask drawn was often not viable as it did not go right the way through the bung. Candidates needed to make sure that the apparatus was completely closed so the gas would not escape. Some candidates thought that hydrogen could be collected by downward delivery or by just measuring how often a lighted splint “popped”. Some candidates wrote about the factors that affect the rate of a chemical reaction, rather than answering the question set.

(c) Many candidates did not know a use of aluminium.

(d) Candidates did not seem to know the advantages of recycling aluminium so could not answer this question very well. Some candidates answered in terms of uses or properties of aluminium.

(e) (i) Some candidates did not write down the name of the substance that had been reduced correctly.

(ii) Some candidates could describe what the diagram showed but others were confused. However, this question was answered much better than similar questions in previous years.

Question 5

(a) (i) Many candidates answered this question correctly.

(ii) Candidates struggled on this question. Some candidates gave the name of a particular alcohol such as “ethanol” or “propanol”. Some candidates confused other organic functional groups, such as alkene, with the alcohol group.

(b) This molecular formula question was not done well. Some candidates made mistakes counting up the atoms and some used superscripts rather than subscripts in the notation. Some candidates put “+” between each element.

(c) Many candidates were able to draw the correct structure of ethanol, including the bond between the oxygen atom and hydrogen atom of the alcohol functional group.

(d) (i) This was a very poorly answered question with lots of candidates struggling with the definition of the term *volatility*. Many candidates just answered with the word “evaporation”.

(ii) This question was answered well with the negative numbers in the table seeming not to present the candidates with problems.

(iii) Almost all candidates answered this question correctly.

(iv) Some candidates found this question challenging. Candidates needed to refer explicitly to the 120 °C in their answers.

(e) (i) This question was answered very well, particular compared to previous years.

(ii) This question was one of the best answered questions on the whole Question Paper. A small number of candidates used atomic numbers instead of mass numbers.

Question 6

(a) Some candidates struggled with interpreting the data in this question and could not select the correct type of steel.

(b) This question was a very well answered question with most candidates realising that **Q** was the alloy. The commonest incorrect answer was **R**.

(c) This question was well answered. Better-performing candidates including references to catalysis and forming coloured compounds.

(d) This equation was successfully balanced by the majority of candidates.

(e) This question was answered well. Some candidates inverted the order of the metals.

(f) (i) Candidates found this question and reading the data correctly challenging. Many candidates confused *rate of reaction* with *time taken*.

(ii) This was a poorly answered question. Many candidates confused *rate of reaction* with *time taken*.

(iii) Candidates struggled with this question and a wide variety of different incorrect answers were seen

(iv) The vast majority of candidates knew the pH of the strong concentrated acid.

Question 7

(a) Many candidates found giving a precise definition in answer to this question challenging.

(b) Very few candidates knew a source or use of sulfur and many candidates confused sulfur and sulfur dioxide. Some answers needed to be more specific.

(c) Many candidates could not name this change of state.

(d) This question was not answered very well. Many candidates needed to be more specific in their answers. The effects on health were particularly poorly addressed.

(e) This question was not answered well. Many candidates did not make use of the information given in the stem of the question. In the filtering stage, it was helpful when candidates clearly specified where each of the components of the filtered mixture went.

CHEMISTRY

Paper 0620/33
Theory (Core)

Key messages

- Many candidates need more practice in answering questions relating to practical procedures including tests for specific ions and molecules.
- Greater accuracy is required in using the correct chemical terminology when answering questions involving structure, bonding, rates of reaction and the particulate nature of gases.
- Candidates should be reminded to read through the questions carefully and to make use of the Periodic Table, where appropriate.
- Candidates should clearly distinguish between rate and time taken in questions involving the effect of concentration on rate of reaction.

General comments

Many candidates answered the majority of questions well, showing a good knowledge of chemistry. A number of questions were left unanswered by some candidates. These commonly included **Question 2(b)** (test for ammonia), **Question 4(a)(i)** (naming an ore of iron), **Question 4(a)(ii)** (explanation of how carbon monoxide is formed in a blast furnace), **Question 5(c)** (extraction of material from a plant) and **Question 7(e)** (crystallisation and purification).

Many candidates need more practice in distinguishing between molecular, ionic and giant structures and understanding the difference between the arrangement and the proximity of particles. Other candidates need to be able to select relevant information from tables of data.

Many candidates need more practice in carrying out simple chemical tests, e.g. the test for ammonia and iron(II) ions. Other candidates need practice in questions involving practical procedures such as determining rates of reaction, the use of solvents to extract materials, and crystallisation to produce a sample of a pure dry crystalline salt.

Most candidates need further practice in questions requiring extended answers, in particular, the inclusion and organisation of specific details (which could be in bullet point form). Some candidates need further practice in using the Periodic Table to answer questions about atomic structure.

Many candidates were able to balance symbol equations and calculate relative formula mass. Other candidates need practice in using the equations given to answer questions about particular reactions. Some candidates also need more practice in calculating relative formula masses.

Comments on specific questions

Question 1

(a) (i) Many candidates were able to identify a noble gas electronic structure. **A** or **D** were the most common incorrect answers.

(ii) A majority of the candidates recognised the electronic structure of a chlorine atom.

(iii) This was almost always answered correctly. A few candidates incorrectly gave **A** or **B**, however.

(iv) Most candidates identified the Group IV element. **A** was the most common incorrect answer.

(v) Many candidates identified the atom of a metallic element. The most frequently seen incorrect answers showed a lack of understanding that most metallic elements are on the left-hand side of the Periodic Table so have 1, 2 or 3 electrons in their outer shells. The most common incorrect answer was **E**. Better-performing candidates referred to the Periodic Table to check that the number of protons and therefore the number of electrons fitted with the metallic or non-metallic nature.

(b) Most candidates calculated the correct number of neutrons in magnesium but few candidates took note of the positive charge on the calcium ion and therefore gave the incorrect answer of 20 electrons. Other candidates added electrons and gave the answer 22. A few candidates gave the mass number, 44. Many candidates worked out the correct number of protons in the two species. Other candidates wrote down the mass number instead of the atomic number.

Question 2

(a) (i) Many candidates calculated the mass of magnesium ions correctly. Other candidates made simple errors in addition or subtraction. The most common errors were to suggest 20 mg or 24 mg.

(ii) A majority of the candidates identified the hydrogencarbonate ion as the negative ion present in the highest concentration. The most frequently seen error was to ignore the word “negative” in the question and suggest the calcium ion.

(iii) Some candidates gave the correct name for the NO_3^- ion. Common errors included nitrogen oxide, nitroxide or nitrate oxide.

(iv) Many candidates were able to calculate the mass of hydrogencarbonate ions present in 250 cm^3 of solution. The most common error was to suggest 5 mg through dividing 250 (cm^3) by 50 (mg) (the mass of hydrogencarbonate present in 1000 cm^3).

(b) Only the better-performing candidates described a correct test for ammonia. Some candidates who did mention litmus suggested, incorrectly, that blue litmus turns red. Many candidates suggested smelling the gas, which is neither a failsafe method nor sensible in terms of safety. Some candidates paraphrased the stem of the question and suggested the addition of sodium hydroxide but added the formation of a precipitate.

(c) Many candidates deduced the correct formula of calcium bromide. Other candidates did not appear to refer to the Periodic Table to find the relationship between group number and formula and so many formulae, such as $CaBr_4$ and $CaBr_6$, were given. The most common error was to suggest CaBr.

(d) (i) Many candidates realised that calcium was produced at the anode and bromine at the cathode. Some responses gave bromide as a cathode product. Some candidates reversed the anode and cathode products. Other candidates incorrectly suggested products such as hydrogen because of confusion with electrolysis of a solution.

(ii) Very few candidates identified a suitable inert substance which could be used as an electrode, other than graphite. Copper and zinc were often suggested as were more reactive metals such as lithium and magnesium. A significant number of candidates suggested that diamond should be used.

Question 3

(a) Many candidates gained full credit for this question. Most candidates gained at least partial credit for the motion of the particles in the three structures. Fewer candidates recognised the type of bonding present with the common suggestion that **P** was covalent or metallic. A significant number of candidates focused on the strength of the bonding rather than the type of bonding. Many candidates did not understand the meaning of the term *arrangement* and wrote about the proximity of the particles instead.

(b) Only the better-performing candidates realised that at a higher temperature, the volume increases. Many candidates only wrote about particles and did not consider what happened to the volume.

Other candidates thought that the volume decreased. A considerable proportion of those candidates who suggested that the particles moved further apart thought that the volume decreased. Other common errors included giving kinetic particle theory answers referring to changes in pressure or concentration, or writing vague statements about the change in force of each individual particle on the walls of the syringe.

(c) Many candidates selected **C** and **D**. Other candidates gave one of these, occasionally selecting **B** as a physical change. Few candidates gained credit for the explanation, either because they wrote "it can be reversed" without any qualification, or did not refer to the fact that "no new substance is formed".

(d) Many candidates gave a correct use of graphite with pencil (leads) being the most frequently seen correct answer. A significant number of candidates suggested "conductor of electricity" despite the fact that a use other than electrical conduction was required. Few candidates made reference to the layers, which appeared in the stem of the question to give candidates a clue. Many candidates gave explanations which were too vague such as "it slides", or "easy to work". A few candidates suggested that graphite is hard.

Question 4

(a) (i) Some candidates correctly identified hematite as the major iron ore. The most common error was to suggest bauxite. A few candidates suggested steel.

(ii) Few candidates gave strong arguments to explain how carbon monoxide is formed in the blast furnace. Many candidates obtained partial credit for the idea that carbon burns in air but few candidates realised how the carbon monoxide forms either by reaction of carbon with carbon dioxide or by incomplete combustion of carbon. Many candidates confused their arguments by including statements about limestone or the addition of pure oxygen.

(iii) Most candidates were able to balance the equation. The most common error was to give $6CO_2$.

(iv) Few candidates gave a clear explanation of how the equation shows the reduction of iron(III) oxide. Many candidates incorrectly referred to the iron and not the iron(III) oxide. The best responses either referred to iron(III) oxide losing oxygen or the iron ions gaining electrons.

(v) Many candidates calculated the molar mass of iron(III) oxide correctly. A few candidates tried to do mole calculations. One common error was to calculate the formula mass of Fe_2O instead of Fe_2O_3.

(b) (i) Many candidates identified hydrogen. The most common error was to suggest either carbon dioxide or oxygen.

(ii) Some candidates gained partial credit for a well-labelled diagram or a suitable explanation but only a minority of candidates referred to timing the reaction. Many candidates did not gain credit because they drew diagrams showing apparatus which would leak or did not show the graduations on an unlabelled gas collector. Many drawings of syringes looked rather like test-tubes or balloons. Other candidates drew connecting tubing as a single line. Other common errors included an absence of a stopper in the flask; the use of a beaker or test-tube open to the air with no collecting apparatus; and imprecise or incorrect labelling.

(c) A minority of the candidates were able to describe a suitable test for iron(II) ions. Those candidates who suggested a suitable test reagent often gained full credit for the green precipitate. The most common errors were to describe a flame test, the addition of a halogen or the addition of nitric acid.

(d) Many candidates did not recognise that recycling is different from reusing. Many candidates selected alternative uses for the steel rather than advantages in terms of conservation of materials or energy. There were many vague answers such as "keeps the same form" or "easier to obtain". Many candidates who did understand that answers about the conservation were required did not give sufficiently precise answers, e.g. "saves the environment" or "you don't have to extract the iron".

Question 5

(a) Many candidates identified the COOH group but some candidates included the adjoining CH_2 group. The most common incorrect answer was to circle the C=O group.

(b) Some candidates deduced the correct molecular formula. Other candidates made simple errors in counting the atoms. $C_2H_3O_3$ was a common incorrect answer. Some candidates did not gain credit because they wrote partial molecular formulae, e.g. CH_2COOH_2.

(c) Very few candidates understood how to extract materials from a plant by grinding/using a mortar and pestle. Only the better-performing candidates suggested adding a solvent to extract the chemicals and very few candidates mentioned filtration. The most frequently seen errors were to suggest direct distillation of the plant material, evaporating the plants or heating the plants.

(d) Some candidates gave a simple definition of the term oxidation by referring to the addition of oxygen. Other candidates gave a definition in terms of electron loss. A significant number of candidates suggested electron gain or made vague statements such as “increases in number”.

(e) (i) Most candidates described the trend correctly. However, some incorrect answers either did not refer to the number of carbon atoms or suggested that the density decreases when the number of carbon atoms decreases.

(ii) Most candidates gave a suitable prediction. Those candidates who did not often gave predictions which were in the range of 170–190 °C.

(iii) Many candidates correctly deduced that butanoic acid is a solid at –10 °C but a significant number of candidates suggested that it is a liquid. Many candidates made errors because of the negative temperatures, thinking that –10 °C is higher than –5 °C. Other candidates gave answers which were too vague, e.g. “it only melts at –5 °C”.

Question 6

(a) (i) Most candidates chose the correct metal. Fewer candidates gave two reasons for the use of iron; high strength was the most common correct answer. Some candidates just quoted figures or gave an imprecise answer such as “its relative strength” rather than stating that iron is strong. The most common incorrect answers usually referred to density.

(ii) Few candidates gave a suitable reason for the use of **M** in the tips of high-speed drills. The most common incorrect answers referred to high strength or high density. Alloy **J** was often incorrectly chosen.

(iii) Few candidates gave a suitable reason for the use of **K** for aircraft bodies. The most frequently seen incorrect answers referred to strength or density. Alloys **J** or **K** were often incorrectly chosen.

(b) (i) Many candidates drew a suitable line of steeper gradient and ending at the same volume as **W** and **X**. Some candidates did not complete the line, showing it decreasing in gradient but not levelling off. Other candidates drew a line that went well above the 80 cm^3 level and then returned to this level. More candidates drew the line finishing at a volume above 80 cm^3. Fewer candidates drew the line finishing below this value.

(ii) Most candidates identified alloy **Y**. The most common incorrect answer was to choose alloy **W**.

(iii) A majority of the candidates were able to deduce how long it took for alloy **X** to lose 40% of its mass. The most common incorrect answer was 1.1 days.

(iv) Most candidates realised that increasing the temperature would increase the rate of mass loss. Better-performing candidates gave a correct answer for the relationship between increased concentration and the rate of mass loss. The most common errors were either to suggest that there would be a lower mass loss or to refer to time rather than rate.

(c) Many candidates selected the correct pH. The most common error was to suggest pH 3.

Question 7

(a) Some candidates completed the electronic structure of water correctly. Other candidates did not draw the electrons in the overlap area. The most common errors included the addition of extra unpaired electrons on the hydrogen or oxygen atoms, or drawing either one or three bonding electrons in the overlap area.

(b) Few candidates gave two suitable physical properties which help distinguish between covalent and ionic compounds. The most common error was to describe covalent and ionic bonding rather than giving suitable properties. Many candidates wrote about malleability or hardness rather than focusing on melting points, electrical conductivity or solubility.

(c) Only the better-performing candidates gained full credit but many candidates gained partial credit from the inversion of one of the pairs of metals.

(d) (i) Many candidates knew the conditions for rusting. Oxygen or air was more commonly given than water. A significant number of candidates suggested that heat was necessary. Many candidates suggested humid conditions, which was an acceptable answer.

(ii) Some candidates gave one suitable way of preventing rust. Others suggested using an alloy or electrolysis, which were not accepted. Many candidates wrote vague statements about coating with an unreactive substance without mentioning the type of substance involved. Another common error was to write about rust avoidance rather than rust prevention, e.g. “store away from oxygen” or “don’t let water touch it”.

(e) Better-performing candidates could describe in detail how to obtain a pure dry sample of copper(II) sulfate from aqueous copper(II) sulfate. Credit was most frequently awarded for the idea of heating to the crystallisation point. Many candidates however just wrote “evaporate” or gave an incorrect answer such as “evaporate to dryness”. A significant number of candidates suggested freezing or placing in a water bath. A few candidates mentioned how the crystals could be washed or dried.

(f) Many candidates balanced the equation correctly. The most common error was to write the incorrect number of water molecules. Attempts to balance with 2, 6 and 8 water molecules were occasionally seen.

CHEMISTRY

Paper 0620/41
Theory (Extended)

Key Message

- Candidates should be reminded of the need to use correct terms and words where applicable, for example, terms such as “residue” and “filtrate”.
- Candidates should try to revisit the entire syllabus during their revision. It was noticeable that many candidates omitted the ionic half-equations in **Question 4(c)**.
- Candidates need to be reminded that if **one** characteristic of a substance is asked for, then no more than *one* should appear in the answer as any incorrect characteristics given may be viewed as a contradiction to correct answers.
- Candidates need to be reminded that a word equation, unless specifically asked for, will receive no credit in place of a correct chemical symbol equation.
- Some good examination techniques was seen, such as the underlining of command words in the questions. However, some responses were a rewriting of the question. Candidates should look to make answers concise and keep to the space available. The use of bullet points rather than long rambling paragraphs helped many candidates cover the key points in **Question 3(c)** and **6(f)**.

General Comments

Candidates seemed well prepared for the Question Paper. Some candidates provided answers which were too general.

Comments on specific questions

Question 1

(a) The majority of candidates gained full credit for this question. Some definitions were not worded precisely enough.

(b) Most candidates were aware that the hydrogen atom has no neutrons although a sizable minority of candidates referred to hydrogen being the first element or it not being a member of a group.

(c) Most candidates scored highly on this question. Only the better-performing candidates correctly deduced the numbers of subatomic particles for the ions.

(d) (i),(ii) Both of these formulae were well known by candidates. Some candidates left the ionic charges explicit in the formula of Sr_3P_2.

Question 2

(a)(i)–(vi) Some candidates were unsure of the identity of some of the oxides. The more common errors were suggesting that CO_2 was a neutral oxide and that Cl_2O_7 was a coloured oxide.

(b) (i),(ii) Many candidates gave very good explanations of an amphoteric oxide including its acidic and basic properties as a result of reacting with bases and acids respectively.

To secure credit for **(ii)**, candidates needed to go beyond stating that the oxides were not acids or bases by stating that they would not react with acids or with bases.

Question 3

(a) (i) A significant number of candidates missed the essential point that it was an *observation* that was required and offered responses such as "the magnesium carbonate stopped reacting" (a repeat of the question).

(ii) A wide variety of incorrect residues were identified such as magnesium sulfate, lead sulfate, sulfuric acid and water.

(iii) Only a small proportion of candidates were able to state that a saturated solution holds the maximum amount of solute. Even fewer candidates knew about the temperature dependency. Some candidates wrote confused answers about saturation in organic compounds.

(iv) Many candidates simply repeated the information given in the question. Very few candidates showed awareness that solubility is temperature dependent and explained that this was why crystallisation occurs during the cooling of a saturated solution.

(b)(i)–**(iii)** A significant majority of candidates were able to determine the number of moles of water removed on heating, but fewer candidates were successful in determining the number of moles of anhydrous magnesium sulfate remaining in the crucible. The whole number ratio of $MgSO_4$:H_2O required was frequently seen as a non-integer ratio.

(iv) Candidates should be familiar with the formula of hydrated salts, such as $CuSO_4.5H_2O$. However, many candidates were unable to convert a 1:7 ratio in **3(b)(iii)** into $MgSO_4.7H_2O$.

(c) This question was about how to make an insoluble salt, lead sulfate, from two soluble salts, lead nitrate and sodium sulfate.

Most candidates did not get beyond the filtration stage in their method as, instead of simply rinsing the residue and drying it, they discussed making the insoluble salt by crystallisation of the filtrate. Other candidates decided that they would start from reactants other than the ones given in the question. Candidates were asked to include a series of steps in their answer but very few candidates did. Many methods were repetitive and did not place the processes in the correct chronological order.

(d) Only the better-performing candidates were able to attempt the ionic equation for the formation of $PbSO_4$(s). Most candidates attempted the full equation but used the wrong formulae, wrong states or left the equation unbalanced.

Question 4

(a) (i) Most candidates knew that zinc sulfide is roasted in air, although oxygen featured often in candidates' answers.

(ii) This equation was relatively well known

(b) (i) Candidates generally realised that, as this is an industrial extraction, coke would be the reducing agent added.

(ii) The processes used in the manufacture of zinc were not well known. Most candidates assumed that it dripped out of the bottom of a furnace. Other candidates omitted to include the subsequent condensing of the zinc to allow collection.

(c) (i),(ii) The idea of why electricity is produced when two different metals are placed into a solution of dilute sulfuric acid was not understood by many of the candidates. Some candidates omitted this question.

Some candidates gave the two ionic half-equations for the electrolysis of dilute sulfuric acid. Other candidates assumed that zinc and copper would be deposited from the acid solution. Only the better-performing candidates realised that it must be H^+ ions gaining electrons to form H_2 molecules at the copper electrode.

(iii) Most candidates suggested that the bulb would glow dimmer and could relate this to the relative reactivity of copper and iron.

Question 5

(a) This relatively straightforward question was answered correctly by most candidates. A small number of candidates listed a balance instead of apparatus for measuring gas volumes.

(b) This question proved difficult for candidates.

(c) Candidates performed well on this calculation. Failing to convert cm^3 to dm^3 was a common error, leading to 7.5 moles of CO_2. Some candidates were only able to gain credit for determining the relative molecular mass of $BaCO_3$.

(d) Most candidates drew good graphs showing a lower initial gradient. Most candidates knew that the decreased rate was a consequence of lumps of barium carbonate having a smaller surface area than the powder.

(e) Candidates did well at drawing the new graph. However, the explanations for the increased rate were less successfully attempted. Most candidates made basic statements about “more particles” and “more collisions” but did not mention “per unit time”, or gave contradictory statements about particles gaining energy.

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

Question 6

(a) The meaning of *hydrocarbon* was well known.

(b) Most candidates could give at least two characteristics of a homologous series. Candidates should avoid writing more than the required number of characteristics as any additional incorrect characteristics may be viewed as contradictory to the correct responses.

(c) Many candidates assumed that ethene was the second member of the alkene homologous series. These candidates were still able to gain credit for the structure of ethene *error carried forward* if it were drawn correctly.

(d) The name of the catalyst was not required for this question, although many candidates named a suitable catalyst, such as phosphoric acid. Many candidates gave unsuitable names for a catalyst, such as nickel or vanadium. Many candidates chose water as the reagent; this was accepted only if a temperature in excess of 100 °C was given.

(e) (i) Butanoic acid was known by many candidates but many errors in the structures were seen. Common mistakes included using a chain of 5 carbon atoms or inserting an extra hydrogen atom on C1. Candidates were asked to draw all of the atoms and all of the bonds; this instruction was not followed by all candidates.

(ii) This proved a difficult question. Some candidates were able to name potassium manganate(VII) as the oxidising agent but omitted to state that the oxidising agent needed to be acidified.

(iii) Although the reagent for the conversion of ethanol to ethanoic acid was often not known in **(e)(ii)**, many candidates were able to describe the change as “oxidation”. “Hydration” was the most common incorrect answer given.

(f) Almost all candidates were able to name at least one reactant; many candidates correctly named both reactants.

The essential reaction conditions were "heat" and "catalyst". As this was a school laboratory preparation, temperatures in excess of 100 °C were not accepted, nor mention of elevated pressures. The name of the catalyst was not required although many candidates named a suitable catalyst such as (concentrated) sulfuric acid. Many candidates gave unsuitable names for a catalyst, such as nickel or vanadium.

Only the better-performing candidates could construct an equation for the reaction. Either molecular or structural formulae for the organic species involved were accepted, such as $C_3H_6O_2$ or CH_3COOCH_3, but "mixed" formulae, such as C_2H_6COO, were ambiguous and not accepted.

CHEMISTRY

Paper 0620/42
Theory (Extended)

Key Messages

- Candidates should ensure they are familiar with the meanings and definitions of important chemical terms on the syllabus, such as element, compound, ion and isotope.
- The concept of intermolecular forces needs further attention since it was often misunderstood and confused with other types of bonding (particularly covalent bonding).
- Candidates should ensure that they are aware of differences between physical changes/properties and chemical changes/properties.

General Comments

There were many good answers to the questions. However, on occasion, it was difficult to read candidates' responses. If candidates wish to change an answer, they should cross out the initial answer and rewrite the answer clearly in a suitable space.

Comments on Specific Questions

Question 1

(a) (i) This question was answered well. Simple distillation was seen occasionally.

(ii) This question was answered very well.

(iii) This question was answered well. Hydration and cracking were common incorrect answers.

(iv) This question was answered less well than the other parts of **(a)**. Electrolysis and evaporation/condensation were occasionally seen amongst the correct answers. Fractional distillation was a common error.

(v) This question was answered well.

(b) (i) Better-performing candidates started their answer with "An element is a *substance* …". There were many candidates who suggested that an element is an atom. Other candidates attempted an explanation based on the Periodic Table. There were many candidates who stated that elements could not be changed *physically* rather than *chemically*.

(ii) Those candidates who referred to compounds containing more than one element usually omitted to refer to chemical combination of the elements.

(iii) The better-performing candidates defined an ion as a particle containing unequal numbers of protons and electrons. These candidates recognised that both atoms and molecules are uncharged particles; charged particles alone could refer to protons or electrons.

Question 2

(a) The fact that isotopes are *atoms* was omitted by the majority of candidates. There was occasional confusion between isotope and isomer.

(b) This question was answered extremely well.

(c) (i) *Giant covalent* is incorrect when applied to bonding rather than structure. Covalent was known by the majority of candidates. It was advisable for candidates to write one word (covalent) in answer to this question. Additional words sometimes contradicted an otherwise correct answer.

(ii) Most candidates gave correct answers here. There were many suitable properties that candidates could have chosen. It was therefore a good idea to choose two that could be justified with suitable reasons. Lack of solubility is difficult to explain at this level, as is brittleness.

(d) (i) Many candidates referred to incomplete combustion or combustion in insufficient air or oxygen. However, the substance undergoing incomplete combustion was often omitted.

(ii) While many candidates answered correctly, a number of candidates attempted to go on to give unnecessarily complex reasons concerning the effect of carbon monoxide on haemoglobin or the oxygen-carrying capacity of blood. Some answers which just said that carbon monoxide was "harmful" were too vague for credit.

(e) (i) The terminology used to describe different types of structure was only known by a minority of candidates.

(ii) This question was only answered well by the better-performing candidates. There were many references to intermolecular forces in silicon(IV) dioxide. Although carbon dioxide molecules do contain covalent bonds, reference to them was almost always inappropriate.

(f) The formula of sodium silicate was occasionally seen as $NaSiO_3$. Sodium and hydrogen were often seen as products. Some candidates were unaware that equations must be balanced.

Question 3

(a)(i) This question was answered well. Units were occasionally omitted. Inappropriate abbreviations for units, e.g. amp/atmp/atp were seen occasionally.

(ii) This question was answered well. Vanadium(V) oxide was sometimes seen along with catalysts for other processes.

(b) (i) This question was answered extremely well.

(ii) Only the better-performing candidates knew that the yield of product would be too low. The phrase "equilibrium shifts to the endothermic side" was sometimes seen and could not be credited because the answer should also have stated which direction was being referred to. It was acceptable to say that equilibrium shifted to the left-hand side at higher temperatures. There was confusion between equilibrium and rate in some cases.

(iii) This was answered better than **(b)(ii)**. Many candidates knew that the rate of reaction would be too low. Some candidates gave an incorrect comment about yield as well as a correct comment about rate. There was confusion between equilibrium and rate in some cases.

(c) This question was answered reasonably well. Some candidates started with NO_2 instead of NO.

(d) It was important to ensure that the copper(II) carbonate was in excess, by adding it to the nitric acid until it stopped dissolving and no more bubbles of gas were seen. Since copper(II) carbonate is insoluble in water, it was inappropriate to carry out a titration which many candidates did. The question referred to solid copper(II) carbonate. Many candidates added the nitric acid to the copper(II) carbonate instead of doing it the correct way around. Some candidates who performed well omitted the equation in otherwise strong answers.

Question 4

(a) Although there were some extremely good answers which gained full credit, the most common error was to list physical properties as well as, or instead of, the chemical properties.

(b) There were some excellent answers which were fully correct. Common errors were the omission of the name of the alkali used or to use an acid instead of an alkali.

(c) (i) There was a wide variety of answers. Zinc ions were sometimes seen on the left-hand side. Incorrect species containing zinc were also seen, including some having negative charges. Equations containing copper were also common.

(ii) This question was often answered correctly. The most common error was to have nickel and copper in the wrong places, suggesting that the magnitude of the cell voltage had been ignored.

(iii) This question was answered well by many candidates. There was a wide variety of answers. Some common errors in the cell voltage were 0.51 V and 0.24 V.

Question 5

(a) (i) This question was answered very well. There were no common errors, although all crosses or all ticks were occasionally seen.

(ii) Formulae were often incorrect. Symbols for halogen atoms rather than the formulae of halogen molecules were commonly used. KCl_2 and KBr_2 were also frequently seen. Candidates need to remember that all equations must be balanced.

(b) (i) This question was usually correct. Yellow and cream were sometimes seen.

(ii) This question was almost always correct.

(iii) This question was often correct, although not all candidates used the mole ratio in the equation.

(iv) Not all candidates recognised that they were supposed to use the answer to **(b)(iii)** to deduce the whole number ratio. Many candidates did not use the whole number ratio to write the formula.

(c) (i) This question was answered reasonably well. Candidates needed to use their knowledge of the trends in Group VII to predict that astatine was a solid.

(ii) NaAt was usually given as the correct formula of sodium astatide. However, "At" was more often seen than "At_2" as the formula for astatine (see also the comment for **(a)(ii)**).

(d) (i) This question was answered very well.

(ii) This question was answered very well.

(iii) This question was answered well. Not all candidates subtracted **(d)(ii)** from **(d)(i)**. Those candidates that did occasionally omitted the negative sign.

Question 6

(a) (i) This question was answered very well.

(ii) This question was answered very well.

(b) It was extremely common to see propanoic acid and propyl ethanoate given as answers. In these cases candidates had ignored the word "type" in the question and gave the names of the products themselves, as opposed to the generic terms requested.

(c) (i) This question was answered reasonably well. Better-performing candidates gave observations, as opposed to a statement identifying what is produced such as "gas given off" or "carbon dioxide is produced". Candidates should have deduced that the addition of aqueous bromine and a solution of sodium carbonate would give the same reactions with the C=C and the $–CO_2H$ groups in the prop-2-enoic acid as they would do with individual alkenes and carboxylic acids respectively.

(ii) This question was generally answered well. The polymers that were drawn often showed more than one repeat unit.

CHEMISTRY

Paper 0620/43
Theory (Extended)

Key Messages

- Candidates should be reminded to read questions carefully to ensure that they answer the question as it has been set.
- Candidates are expected to know that some commonly encountered elements are diatomic (chlorine, bromine, iodine, nitrogen, oxygen and hydrogen being the most commonly encountered).
- Working should be clearly shown. This allows method marks to be awarded in calculations even if the final answer is incorrect.
- If candidates use technical terms, such as filtrate or intermolecular, then they need to ensure that they do not then contradict the term used.
- When calculating the number of moles of a gas, candidates are expected to use the molar volume of gas at r.t.p. ($24\,dm^3$), as stated on page 16 of the Question Paper. Candidates should not be using the ideal gas equation.

General Comments

There were many good answers to the questions set. Some candidates provided answers which were too general.

Comments on Specific Questions

Question 1

(a) All parts of **(a)** were well answered, although **(vi)** proved more challenging than the other parts.

(b) (i) This question was generally well answered, although some candidates mixed up protons and neutrons. Correct statements about electrons were ignored, but some candidates stated that the number of electrons was different. There was some confusion in a few answers between the terms *isomers* and *isotopes*.

(ii) Most candidates could identify the two isotopes.

(iii) While most candidates gave a correct answer, some answers lacked the required information and simply stated that isomers have identical chemical properties because they are the same element.

Question 2

(a) (i) A large number of candidates gave the molecular formula of cyclopropane rather than the empirical formula requested. A few answers included “Br”, suggesting the candidates had not read the question carefully and were giving a formula of the product.

(ii) Although candidates were not expected to have knowledge of cyclopropane, they were expected to use the information provided in the question and their knowledge of the colour of aqueous bromine and the reaction of bromine with alkenes to answer this question. Despite the information in the question, a significant number of candidates insisted that cyclopropane would not react with aqueous bromine and so the colour would not change.

(b) (i) This was generally only answered well by the better-performing candidates. While most candidates were able to draw a suitable line to represent the energy of the products in this exothermic reaction, the labelling of the energy change, ΔH, was often inaccurate. Even those candidates who knew it was the energy difference between the reactants and products often failed to put an arrow pointing in the correct direction on the line.

(ii) While many fully correct answers were seen there were a number of common errors. The most common errors were reversing the subtraction or failing to include one (or more) of the C–C bonds in the calculation. There were also a number of simple arithmetical or transcription errors. Candidates should be encouraged to check their working when they have completed each question. Where a final answer was incorrect, credit was awarded for the method used in the calculation where the working was clearly shown.

(c) The most common error was to compare the strength of the covalent bonds. Of those candidates who referred to intermolecular forces, some then contradicted themselves by saying that the intermolecular forces were between atoms. When explaining why something is bigger or smaller than something else, the language used in the answer needed to be comparative, such as saying “the intermolecular forces are stronger” rather than “the intermolecular forces are strong”.

Question 3

(a) Most candidates gained credit for stating there was a “sea of delocalised electrons”. However, relatively few candidates described the attraction between the electrons and the positive ions or the fact that the positive ions were arranged in a lattice. It was not uncommon for the bonding to be described as “ionic” or “covalent”. Some candidates wrote at length about various properties of magnesium that were not asked for in the question.

(b) While the majority of candidates could relate the electrical conductivity to being due to the electrons, fewer candidates could state that the electrons were mobile and could move throughout the structure. Many candidates limited their answer to the electrons being delocalised which was insufficient, as many organic compounds contain delocalised electrons but are not conductors of electricity. Some candidates seemed confused by the nature of an electric current and described how electrons pass charge from one electron to another and so enable the material to conduct. This was incorrect as the electrons are charged and their movement in a given direction is the electric current. They do not pass charge on.

(c) This was well answered with the majority of candidates referring to layers of suitable particles being able to slide over each other.

(d) (i) The two most common errors were to omit the charges of the two ions formed or not to show the two electrons gained by sulfur as being derived from the magnesium (shown as “×” since the magnesium’s electrons were shown using this symbol in the diagram given).

(ii) Most candidates knew that the magnesium sulfide would have to be molten to conduct electricity but few candidates went on to answer the second part of the question correctly. The most common error was to state that the electrons were able to move.

Question 4

(a) This question proved challenging to many candidates. Common incorrect answers were “petrol” (not the same as petroleum) and “oil” (not the same as “crude oil”).

(b) (i) While most candidates gained some credit, common errors included saying that a hydrocarbon was a mixture or omitting the fact that hydrocarbons contain *only* carbon and hydrogen.

The meaning of “saturated” caused problems for some candidates. A common error was to say that “each carbon has as many bonds as possible” or that “each carbon is bonded to as many hydrogen atoms as possible”. The required definition was that all carbon to carbon bonds are single bonds.

(ii) This question was very well answered.

(iii) While many fully correct answers were seen, it was not uncommon for candidates to mix up physical and chemical properties. It should be noted that members of a homologous series have the same general formula but not the same chemical, molecular or empirical formula.

(iv) Most candidates who identified carbon dioxide and water as the products gained full credit by also correctly balancing the equation. The most common error in balancing was to have 22 as the stoichiometric coefficient for oxygen. Presumably these candidates had not noticed that oxygen was diatomic.

(c) (i) This question was well answered. Most candidates selected acid rain as the environmental problem but many candidates also knew about photochemical smog.

(ii) Most candidates were able to state that incomplete combustion formed carbon monoxide. However, there were a number of answers stating that the nitrogen involved in the formation of oxides of nitrogen came from the fuel rather than from the air.

(iii) Most candidates were aware that carbon monoxide was toxic and some excellent answers based on the formation of carboxyhaemoglobin were seen. However, some candidates incorrectly claimed that carbon monoxide prevented blood flowing or gave unacceptable vague answers such as "causes respiratory problems".

(iv) Some clearly set out and detailed answers were seen, complete with fully correct equations. However, there were many less detailed and less precise answers. It was common in the equation to show nitrogen as monatomic and some candidates suggested that nitrogen reacted with oxygen in the catalytic converter to form oxides of nitrogen.

(d) (i) Most candidates were able to recognise and name butane.

(ii) This definition was not well known. It was common to see incorrect terminology to describe the formula such as "empirical", "chemical" or "general", rather than the correct "molecular formula".

(iii) This was only answered well by the better-performing candidates. Most candidates were able to give the conditions required for the reaction. However "light" on its own was insufficient. The structures of the products were very often incorrect. Incorrect numbers of bonds from each atom were common, as were structures based on **A**, rather than **B**. It was clear that many candidates did not understand the terms "organic" and "not organic" since they drew two organic products. Where an inorganic product was attempted this was often incorrectly shown as a hydrogen molecule.

Question 5

(a) (i) The definition of oxidation in terms of electrons was well known.

(ii) There were relatively few fully correct ionic equations. It was common to see equations with Ni^{2+} on the left, despite the question asking for the oxidation of nickel. In some equations the number of electrons was unbalanced, while in others the electrons were being added rather than taken away. A common error was the use of "N" as the symbol for nickel.

(iii) While the majority of candidates could state that the mass of the nickel electrode would decrease, some candidates gave a reason for their answer, which was not required. A significant number of candidates incorrectly attributed the mass loss to the loss of electrons.

(b) (i) Better-performing candidates gave correct answers with clear explanations relating to the data in the table. The most common error was to identify vanadium as the most reactive based on the fact it produced the most positive potential difference.

(ii) This question was very well answered.

(iii) Most candidates realised that beryllium was more reactive than silver and so predicted a negative voltage. Relatively few candidates could work out the value using the data in the table. The most common prediction was a value between –1.6 V and –0.7 V, presumably because these were the numbers either side of the blank in the table.

(c) This question was very well answered by better-performing candidates. The most common approach was to set up a cell using magnesium as one electrode and beryllium as the other and then to look at the sign of the potential difference.

Question 6

(a) (i) It was not unusual to see oxygen given incorrectly as one of the products of this thermal decomposition.

(ii) While candidates were not expected to recall the actual pH of the solution formed when barium oxide is added to water, they needed to realise that, as this is the oxide of a Group II metal, the solution formed will be alkaline. However, the pH scale in water does not continue to infinity and so answers that were unlimited (such as “greater than 7”) did not gain credit.

(iii) While the majority of candidates named oxygen as a product, very few candidates were able to identify nitrogen dioxide as the other gaseous product. Common incorrect products included nitrogen and various ionic compounds of barium.

(b) (i) This question was generally not well answered. Only a minority of responses correctly showed the formula of sodium nitrate.

(ii) This type of practical procedure should be familiar to candidates. However, two common errors were: ignoring the information at the start of the question and treating barium carbonate as soluble, thereby trying to crystallise it from a filtrate; and confusing the terms *residue* and *filtrate* and so trying to wash and dry the filtrate, which would not work.

(c) (i) If a candidate calculated the relative formula mass (M_r) of barium carbonate incorrectly, then the error they had made was carried forward and credit could still be awarded for the use of this incorrect M_r in calculating the number of moles subsequently. However, this could only be done if the candidates’ working could be followed. The use of words to support the steps taken in calculations is strongly recommended. This could be as little as “The M_r $BaCO_3$ = …”.

(ii) Most of the better-performing candidates used the ratio in the equation correctly and so could correctly give the number of moles of carbon dioxide.

(iii) This question was well answered by the better-performing candidates.

(iv) Most candidates who made progress with the calculation did not use the 1:2 ratio in the equation and so simply subtracted the moles of barium carbonate in **(i)** from the moles of hydrochloric acid used and so got the answer 0.20, rather than 0.15.

CHEMISTRY

Paper 0620/51
Practical Test

Key messages

- In qualitative analysis exercises, candidates must follow the instructions given and record all observations. Candidates should be aware that the mark allocation reflects the number of points to be made and should this to guide them in their answers.

- Candidates would benefit from practice in adding aqueous silver nitrate to solutions of different halides to compare the colours of the precipitates formed. This would help them to be able to distinguish the three different silver halide precipitates.

General comments

The majority of candidates successfully attempted and completed all questions.

Generally, Supervisors submitted results for **Questions 1** and **2**, though a few did not carry out **Question 2**.

Few problems were reported by Centres with regard to obtaining the chemicals and preparing the solutions. A number of Centres recorded unexpected volumes of aqueous sodium thiosulfate in Experiments 1 and 2 in **Question 1**. Centres should ensure that the Confidential Instructions, which clearly specify the concentrations of the solutions for **Question 1**, are carefully followed.

There was some evidence that some Centres had not prepared candidates to carry out a flame test for the qualitative analysis in **Question 2.**

Comments on specific questions

Question 1

(a), (b) The table of results was completed by all of the candidates. A minority of candidates recorded initial burette readings greater than the final burette readings. Some candidates recorded volumes to the nearest whole number only. Burette readings should be recorded to one decimal place. There was sometimes a wide variation in the results produced by different candidates from the same Centre.

(c) Incorrect colours such as blue, black, yellow or colourless were frequently given.

(d) Many correct answers referred to the solution going lighter or turning yellow.

(e) Yellow to blue/black was the expected colour change. References to green were ignored. Some candidates confused the initial and final colours. Answers such as “yellow to colourless” showed that candidates had not read the question carefully.

(f) (i) Answers such as “solution **D** was the more concentrated because a smaller volume of sodium thiosulfate was used” showed a lack of understanding. Better-performing candidates realised that solution **C** was more concentrated as a greater volume of sodium thiosulfate was used. Some less clear answers discussed the difference in the rate at which the two solutions reacted, i.e. **C** reacted faster.

(ii) A ratio or some quantitative indication was required in the comparison. A majority of candidates recorded a correct ratio from their results, often rounded to the nearest whole number.

(g) Credit was awarded for the answer obtained from the difference for Experiment 2 in **(b)** multiplied by 1.5. Some candidates referred to "about" or "almost", showing a lack of working. The unit was sometimes not given.

(h) (i) Many irrelevant responses were mentioned. Temperature, timing, rinsing the conical flask, weighing potassium iodide and human errors were ignored. Credit was given for the use of a measuring cylinder, not repeating the experiments and going past the end-point.

(ii) Meaningful improvements, linked to **(i)**, gained credit.

Question 2

(a) Generally, the appearance of the solid was correctly described as green or green/blue. The inclusion of the term *solution* or *precipitate* negated a correct answer for the colour.

(b) Detailed observations were only seen from the better-performing candidates. The presence of condensation/droplets of water was often not noticed. Vague references to gases being given off were most common. A colour change to black was frequently recorded.

(c) (i) The obvious observation of fizzing, bubbles or effervescence was often omitted. Incorrect gas tests were common. Instantaneous effervescence when an acid is added to a solid should have prompted candidates to test for carbon dioxide. Credit was awarded for limewater turning milky and the formation of a blue solution. This was often poorly described as a blue precipitate.

(ii) Some candidates did not add aqueous ammonia gradually and missed the initial blue precipitate. The use of the terms *soluble*, *insoluble*, *dissolves* and *solution* was often confused. References to layers showed a lack of practical experience in not shaking the mixture as the reagent was added.

(d) This was generally correctly answered. However, some candidates had clearly never performed a flame test and gave answers such as "lighted splint pops".

(e) This question was well answered. Copper(II) carbonate scored full credit. Sodium carbonate gained partial credit, if a yellow or orange colour was given in **(d)**.

(f) Generally the appearance of the solid was correctly described as white. Descriptions such as "colourless" or "grey" could not be credited. The inclusion of the term *solution* or *precipitate* negated a correct answer for the colour.

(g) (i) References to a change in the mixture, for example colour changes, bubbles or the formation of a white precipitate could not be credited.

(ii) The addition of aqueous silver nitrate should have resulted in a yellow precipitate. A significant number of cream/white precipitates or yellow solutions were recorded. References to being milky or cloudy were ignored.

(h) This question was usually answered correctly with a lilac/pink flame recorded. Red and purple descriptions of the flame could not be credited. Some candidates seemed never to have performed a flame test.

(i) Only the better-performing candidates scored full credit. Many candidates concluded that solid **F** was a sodium or lithium salt. The presence of a halide ion was recognised and credited according to the recorded observation in **(g)(ii)**.

Question 3

(a) Vague references to the use of indicators without an expected result were common and were not credited. Some candidates thought that smell was acceptable as a test for ammonia. Litmus turning blue was the most common correct answer.

(b) (i) This question was generally well answered. The majority of candidates realised that (fractional) distillation was the most suitable method to obtain pure water from the mixture.

(ii) Filtering the mixture to obtain sand was commonly given. However, many candidates did not realise that, to obtain pure sand, the residue also needed washing with water and drying using a suitable method. Leaving to dry was not sufficient. Reference to (fractional) distillation, evaporation and crystallisation of the mixture to obtain the sand showed a lack of knowledge and understanding.

CHEMISTRY

Paper 0620/52
Practical Test

Key messages

- Candidates should follow the instructions provided. When the instruction is to leave the mixture to stand for a certain amount of time, this is to help the candidates to be able to make the expected observations.
- Where a test is in two (or more) parts, it is best to give observations after each part, rather than just an observation pertaining to the final product.
- Centres should ensure that they use starch solution that gives an obvious blue-black colour when added to a solution containing iodine.
- Candidates should be aware of how to conduct a flame test.
- When two solutions react together to form a solid, the mixture will become cloudy. Candidates should be reminded that the solid formed should be called a *precipitate*.

General comments

There were somevery strong answers to questions and candidates appeared to be well prepared for the planning question, **Question 3**, which was generally well answered.

Parallax errors in reading the scale from apparatus means that the user is not using the apparatus correctly; it is not a fault or problem with the apparatus. Parallax errors are not regarded as a source of error in chemistry experiments.

Comments on specific questions

Question 1

(a), (b) The majority of candidates obtained results that were in acceptable agreement with the Supervisor. The most common errors seen were failure to record all readings to one decimal place or swapping over the initial and final burette readings.

(c) (i) The correct colour change was often seen, although some candidates swapped the two colours over. A small but significant number of candidates recorded colours that just were extremely unlikely with the reagents used.

(ii) Having completed the experiment, the majority of candidates were aware that, because there was a colour change already at the end-point, potassium manganate(VII) was self-indicating.

(d) (i) With questions of this type, candidates need to think whether the solution in question is in the conical flask or the burette. Here the question concerned the solutions in the conical flasks, and so a larger titre meant that the solution in the conical flask was more concentrated. A significant number of candidates stated that solution **B** was more concentrated as less of solution **A** was required. Some candidates explained their answer in terms of time rather than the volume of solution **A** required. These candidates did not receive credit for their explanations.

(ii) This was generally correctly answered, but sometimes there was incorrect rounding of numbers.

(e)(i) This was very often correct. However, a common cause for not gaining full credit was failing to state the actual volume of solution **A** that would be required.

(ii) While many candidates realised that the burette would not be big enough, many candidates said that the solution was to use a measuring cylinder rather than a burette in the titration.

(f) A number of candidates thought that measuring cylinders were more accurate than pipettes. A significant number of candidates said that the advantage of a measuring cylinder was that it could measure more than one fixed volume. While this is true, it is irrelevant in this case since the question involved measuring out $25\,cm^3$ of solution **B**/**C** only.

Question 2

(a) The flame test colour was usually correct. However, some of the answers seen suggested that candidates had tested the solid with a lighted splint or heated it in a test-tube.

(b) In almost all cases the difference between the final and initial temperatures was worked out correctly. However, some candidates recorded a final temperature higher than the initial temperature. Given the fact that the dissolution of hydrated sodium thiosulfate is endothermic, this was not a correct observation.

(c) While most candidates noted the change in colour of the filter paper soaked in aqueous potassium manganate(VII), the yellow precipitate formed was less commonly noted. A small number of candidates conducted other tests (such as lighted splints or the use of litmus paper) that were not asked for. These were ignored.

(d) There should have been no change observed when aqueous sodium hydroxide was added to the sodium thiosulfate solution. Despite this, a range of precipitates and bubbles were noted by some candidates.

(e) (i) For some candidates the mention of copper(II) sulfate in the question led them to report seeing light blue precipitates which dissolved to give dark blue solutions. This was not expected, given the reagents used. Candidates should follow the instructions and record the actual observations made.

There were three stages to this test and ideally there would have been three observations. The first observation after adding the aqueous copper(II) sulfate to the aqueous potassium iodide, the second observation after adding starch to the product, and the third observation after leaving it to stand for 5 minutes. It was evident from some of the observations recorded that, in a few instances, candidates selected the wrong solutions to mix together.

(ii) While a small number of candidates reported no change, many reported either a colourless solution or a white precipitate. If the instructions are followed, then the blue-black colour will disappear leaving a colourless solution with a white precipitate at the bottom.

(f) Many fully correct answers were seen, although sulfate and sulfide were sometimes seen in place of sulfite, as was iodide (presumably due to the yellow precipitate in **(e)(i)**). Candidates are advised to give a name rather than a formula where they are not asked for the formula of the compound.

(g) While most answers were correct, some unexpected flame colours were seen. Some of the answers given suggested that candidates had tested the solid with a lighted splint or heated it in a test-tube.

(h) This was very often correct, although some answers omitted the term “precipitate”.

(i) Despite no reaction being expected, as was recorded by the majority of candidates, some candidates claimed to have seen bubbles or precipitates or produced strong smelling gases.

(j) As in **(f)**, candidates are advised to give a name rather than a formula where they are not asked for the formula of the compound.

Question 3

This question produced some excellent answers as well as some rather inventive ones. The most common approach to the problem was to react the mixture with hydrochloric acid, isolate the unreacted kaolinite and determine its mass. The most common omissions in this method were the need to use excess acid, the need to wash the residue from filtration and the need to dry the residue prior to weighing.

Some candidates tried to determine the mass of calcium chloride formed by evaporation of the filtrate. This method will not work as calcium chloride crystals contain water of crystallisation and some of this will remain in the solution after crystallisation. Even if an accurate mass of calcium chloride could be found, a calculation involving molar masses would then be required.

CHEMISTRY

Paper 0620/53
Practical Test

Key messages

- Candidates should be reminded that when there is an instruction to label graph lines, all lines should be labelled and not just one of them.
- Graph lines will normally be either straight lines or curves with either an increasing or decreasing gradient or curves that level off. “Best fit” lines are not wavelike curves that both increase and decrease in gradient depending on where the next datum point is.
- Candidates should be reminded that precipitates are specifically solids that have been formed in the reaction between two solutions. It is incorrect to describe a substance as a precipitate just because it is a solid.
- Where a test in is two (or more) parts, it is best to give observations after each part, rather than just an observation pertaining to the final product.
- Centres should ensure that they use starch solution that gives an obvious blue-black colour when added to a solution containing iodine.

General comments

There were some very strong answers to questions and candidates appeared to be well prepared for the planning question, **Question 3** which was generally well answered.

Parallax errors in reading the scale from apparatus means that the user is not using the apparatus correctly; it is not a fault or problem with the apparatus. Parallax errors are not regarded as a source of error in chemistry experiments.

Comments on specific questions

Question 1

(a) Almost all candidates correctly completed the gas volumes in the table with the gas volume increasing as time increased. A small minority of candidates had an incorrect non-zero value at zero seconds and so could not gain full credit. Many candidates reported gas volumes of equal to or greater than 100 cm^3 before the 180 seconds had elapsed. This was perfectly acceptable and full credit could still be awarded.

(b) As in **(a)**, this question was very often fully correct, although again a small minority of candidates had an incorrect non-zero value at zero seconds. Almost all candidates reported the expected slower increase in gas volume than in the first experiment.

(c) The accuracy of plotting of the points was generally good with relatively few errors made. However, the smooth lines were, on the whole, very poorly drawn.

(d) All most all candidates could identify Experiment 1 as having the faster rate. However, while most candidates could suggest a reason why this was the case, some candidates did not read the question with enough care and did not explain how they knew that the selected experiment had the faster rate.

(e) A common error was to read the volume of gas incorrectly from the graph. The calculation was normally completed correctly and, in many instances, correct units were seen.

(f) Some candidates either did not read the introduction to **Question 1** with sufficient care, or they had forgotten the information they were given. Despite being told that the acid was in excess in both experiments, many candidates suggested that the acid had all been used up.

(g) The majority of candidates realised that the reaction would be faster with magnesium powder and could give a correct explanation for this. However, some candidates suggested that the magnesium powder would have a smaller surface area.

(h) A number of candidates thought that an advantage of a measuring cylinder was its high degree of accuracy. Candidates should be aware of the use of volumetric pipettes and burettes for the accurate measurement of volumes of solutions.

(i) The most commonly suggested improvement was to repeat the experiment and take averages.

Question 2

(a) The most common error here was to describe solid **J** as a liquid, solution or precipitate. Solids should not be described as precipitates unless they have been formed in a reaction between two solutions.

(b) (i) While many candidates reported the expected result of the litmus paper being bleached, some candidates seemed to stop testing the gas as soon as the litmus became red, and so missed the required observation. A few candidates reported that the litmus became blue which was an unexpected result given the reagents used.

(ii) While the correct colour of product was often seen, the term *precipitate* was less common. The product was often described as being cloudy. If two solutions are combined and the resulting mixture is not clear, then it is probable that a precipitate has been formed.

In some cases “no change” was recorded. This suggests that insufficient sodium hydroxide had been added to neutralise the remaining hydrochloric acid and that the candidates had not followed the instruction to add an excess of aqueous sodium hydroxide

(c) Despite the fact that the *Tests for gases* on page 8 of the Question Paper lists only two gases that are tested for using damp litmus paper (chlorine and ammonia) and that damp litmus paper was the only test carried out on the gas produced, answers such as carbon dioxide, oxygen or hydrogen were seen. These gases could not have been identified given the test carried out.

(d) There were two parts to this test. The first part involved the addition of iron(II) sulfate to solution **K** and the second part involved the addition of sodium hydroxide to the resulting mixture. Candidates who gave observations after each part usually gave clearer and more accurate answers than candidates who just gave a final observation.

(e) As in **(d)**, there were two parts to this test. Many candidates just gave a final observation after the addition of the starch and did not record any observation after the addition of the aqueous potassium iodide. Most candidates who gave two observations scored full credit.

(f) Some candidates reported the solution becoming pink or purple. This is probably due to a failure to follow the instruction to add a few drops of potassium manganate(VII) solution.

(g) The *Tests for gases* on page 8 of the Question Paper lists only two gas tests involving a splint. Hydrogen is tested for using a lighted splint and oxygen requires the use of a glowing splint. However, it was not uncommon to see answers referring to “a lighted splint relights”. If the splint is already alight then it cannot relight. Some candidates reported the gas as “popping” with a lighted splint which is an unexpected result, given the reagents used.

(h) Many candidates correctly identified the gas as oxygen, although carbon dioxide was frequently also seen, despite this gas not having been tested for.

Question 3

This question produced some excellent answers as well as some rather inventive ones. Some candidates who performed less well opted for fractional distillation, which is not appropriate in a laboratory given the high boiling points of ionic compounds and metals. A common omission was not stating that the cassiterite (which was provided as a large lump) would need breaking down using a pestle and mortar before use.

Better-performing candidates made good use of the information provided on the reactivity of tin and used a displacement reaction to obtain a sample of tin.

For the final part of the answer, candidates were expected to explain how they would use the results obtained to calculate the required percentage of tin. While many candidates did this, some just stated "calculate the percentage of tin" which could not be credited.

CHEMISTRY

Paper 0620/61
Alternative to Practical

Key Messages

- Candidates should be familiar with flame tests. It was clear that many candidates did not know how to carry out this test. A number of candidates confused flame tests with tests for gases. Flame tests should be part of candidates' regular practical work in class.
- Observations are those which you can see. For example, "fizzing" is an observation but "a gas was given off" is not.
- Candidates should not give contradictory answers.

General comments

The vast majority of candidates successfully attempted all questions.

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

Comments on specific questions

Question 1

(a) (i) Some candidates had difficulty identifying the stirrer / glass rod. The stirrer was often referred to as a thermometer or spatula.

(ii) Many candidates correctly named the piece of equipment used to add the solid as a spatula. Some candidates mistakenly identified it as a burette, pipette or measuring cylinder.

(iii) This was generally well answered with the majority of candidates answering nitric acid. "Nitrate acid" was not accepted.

(iv) "Unreacted solid" was ignored as a response because this was given in the diagram. Mention of a colour change was common.

(b) This was only answered correctly by the better-performing candidates. Many answers discussed the exothermic nature of the reaction. Vague answers such as "strontium is very reactive" were common. Better-performing candidates stated that the reaction was fast at room temperature.

(c) There were issues with candidates giving only partial names such as "strontium is in excess" or "carbonate is in excess". Full credit was awarded for recognising that unreacted solid was present. A significant number of candidates incorrectly thought that the strontium nitrate or the dilute acid was in excess.

(d) Many candidates missed the filtration step in their answers and other candidates heated the solution to dryness instead of to crystallisation point.

Question 2

(a) and **(b)** The tables of results were generally completed correctly. Some candidates reversed the initial and final readings while other candidates misread the burette diagrams. These candidates still gained credit for correctly recording the difference between the readings.

(c) (i) Solution **D** was often incorrectly identified as the more concentrated solution with the reason that a smaller volume of sodium thiosulfate solution was used in the titration.

(ii) This question was generally well answered. A minority of candidates did not read the question and worked out the difference in titre volumes between the two experiments.

(d) Most candidates gave a correct unit and better-performing candidates correctly calculated the volume. A wide range of incorrect values was seen.

(e) (i) Many candidates gave vague sources of error concerning washing / rinsing the flask, misreading and other human errors, or not measuring the starch solution. Better-performing candidates referred to going past the end-point.

(ii) Meaningful improvements linked to the errors stated were only occasionally seen. Washing the conical flask with solution **D** was a common incorrect answer.

Question 3

(a) Many answers correctly identified safety issues, such as a possible violent reaction or explosion.

(b) The majority of candidates correctly identified carbon dioxide as the gas given off in **test 2**.

(c) Solid **E** was sometimes identified as a chromium(III) or iron(II) compound instead of copper(II) carbonate.

(d) Solid **F** was potassium iodide which was often correctly described as a yellow or white solid. A significant number of responses incorrectly included the term *precipitate*. Some weaker answers described solid **F** as a solution.

(e) (i) Many answers incorrectly referred to changes such as precipitate formation, effervescence or colour changes.

(ii) Incorrect references to the formation of white or a cream precipitate were common. Other answers mentioned the precipitate dissolving or effervescence and were not credited.

(f) This question was generally well answered. The flame colour from potassium ions is not purple or mauve and this was ignored, where given. A number of responses showed confusion with the sodium flame test and answers were given in terms of a yellow flame.

(g) This question showed a lack of practical experience of a flame test for many candidates. Incorrect methods included putting the solid in a glass container and heating it or testing with a lighted splint. Better-performing candidates suggested using a metal wire cleaned in hydrochloric acid, or a splint to hold the solid in a blue / hot / roaring flame. Holding the solid using tongs, tweezers or forceps is not a practicable method and was not credited.

Question 4

(a) Vague references to the use of indicators without an expected result were common and were not credited. Some candidates thought that smell was acceptable as a test for ammonia. Litmus turning blue was the most common correct answer.

(b) (i) This question was generally well answered. The majority of candidates realised that (fractional) distillation was the most suitable method to obtain pure water from the mixture.

(ii) Filtering the mixture to obtain sand was commonly given. However, many candidates did not realise that, to obtain pure sand, the residue also needed washing with water and drying using a suitable method. Leaving to dry was not sufficient. Reference to (fractional) distillation, evaporation and crystallisation of the mixture to obtain the sand showed a lack of knowledge and understanding.

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Key messages

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

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

General comments

The vast majority of candidates successfully attempted all questions.

The vast majority of candidates were able to complete tables of results from readings on diagrams as in **Question 2** and **Question 3**.

Question 4 was a planning task based on the separation of two substances. There were several acceptable routes, which seemed familiar to candidates. The quality of answers was generally very good.

Comments on specific questions

Question 1

(a) Most candidates gained credit for this question, although incorrect terms such as “gas jar” were seen regularly.

(b) Most candidates appreciated that bubbles would be seen, although some candidates mentioned that the magnesium would get smaller or would dissolve or referred to the level of water in the measuring cylinder getting lower.

(c) This question was answered well, although some candidates misunderstood the question and merely labelled the *x*-axis as “*x*-axis”. A wide range of labelling included concentration, rate of reaction or temperature. Some candidates added a scale to the axis. A significant minority of candidates omitted this question.

(d) Most candidates scored at least partial credit in **(i)**. However, some candidates misread the graph and gave values that were too low. A common error was to state the absolute difference between the values, rather than their ratio.

In **(ii)**, most answers gave differences in the concentration or volume of acid. Some answers suggested catalysis, rather than a difference in the mass of magnesium. Some candidates answered correctly in terms of magnesium but incorrectly went on to suggest different concentrations of the acid.

In **(iii)**, most candidates gained full credit. A common error was to give a final volume of gas that was too high.

Question 2

(a) Most candidates could read the scales correctly, although not recording figures to one decimal place was a common error.

(b) Again, most candidates could read the scales correctly but a number of candidates failed to record figures to one decimal place.

(c) Only the better-performing candidates appreciated that potassium manganate(VII) was an indicator or that it would change colour. Many candidates suggested that the indicator would interfere in the reaction in some way, such as by changing volumes or concentrations. Some candidates suggested "not needed" without further explanation.

(d) In **(i)** most candidates appreciated that solution **C** was more concentrated and explained their choice, usually by stating that more potassium manganate(VII) or solution **A** was used.

In **(ii)**, a large proportion of candidates recognised that solution **C** was three times more concentrated.

(e) A large proportion of candidates gained full credit in **(i)**, although there was a wide range of incorrect values obtained. Candidates sometimes doubled the value of the initial or final volume instead of the volume used.

Candidates found **(ii)** more challenging, with only the better-performing candidates recognising that the problem related to the burette. Those that did recognise this usually gained full credit.

(f) A good proportion of candidates knew the advantages and disadvantages of using a measuring cylinder over other more accurate pieces of apparatus.

(g) The question was well answered with many candidates appreciating that it would be possible to calculate an average. Some candidates incorrectly thought that by repeating readings the person carrying out the experiment would produce more accurate or precise readings.

Question 3

(a) Almost all candidates answered this question well and gained full credit.

(b) A large number of candidates confused *endothermic* with *exothermic*. Some candidates described the change using words other than endothermic.

(c) A wide range of incorrect gases were mentioned in answers to this question.

(d) Better-performing candidates gained full credit for this question. Most candidates identified a sodium compound. Several candidates were close with answers including sulfides, sulfates or incorrect formulae.

(e) A large proportion of candidates appreciated that the flame should be red. The most common incorrect responses were yellow, lilac, orange or brick-red.

(f) Most candidates recognised that a white precipitate would form.

Question 4

There was, as expected, a wide variety of routes mentioned by candidates. The most common method used was the filtration method to obtain kaolinite after reacting the mixture with dilute hydrochloric acid. A lot of candidates failed to appreciate the need for excess hydrochloric acid. Many candidates gained full credit using this method.

The next most common methods were gas collection and mass loss, with some candidates using inventive methods for the calculation part.

Some candidates did not understand the premise of the question and thought that two separate samples, one of calcium carbonate and one of kaolinite, were provided.

CHEMISTRY

Paper 0620/63
Alternative to Practical

Key messages

- Questions requiring candidates to plan an investigation should be answered with details of the apparatus to be used, the method involved and quantitative information clearly specified.
- Observations are those which you can see. For example, "fizzing" is an observation but "a gas was given off" is not.

General comments

The majority of candidates attempted all of the questions.

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

Comments on specific questions

Question 1

(a) (i) Many candidates scored credit for this question. Answers such as *pipette*, *connector* or *condenser* showed a lack of understanding and familiarisation with common laboratory apparatus.

(ii) Most responses gained credit for placing an arrow under the mixture of alcohols. A number of arrows were wrongly placed under the beaker of water.

(b) The majority of candidates gained full credit for realising that the purpose of the water was to condense the alcohol vapour into a liquid. Partial credit was given for the idea of cooling.

(c) A number of responses mentioned that the thermometer's purpose was to measure the temperature of the alcohol vapour / boiling point. A minority of candidates wrongly thought that the thermometer bulb was positioned so as to minimise the danger of it breaking.

(d) This question was well answered by the majority of candidates.

(e) Many candidates did not understand the difference between chemical and physical tests and confused the terms in their answers for **(i)**. Some answers gave a test without the expected result. Adding anhydrous copper(II) sulphate to ethanol and observing no colour change was only given by the better-performing candidates.

In **(ii)**, the idea of finding the melting / boiling point of the liquid was expected. References to burning and smell were common but were not credited.

Question 2

(a) The vast majority of candidates successfully completed the volumes in the table from the measuring cylinder diagrams.

(b) Most candidates plotted the points on the grid correctly, though a significant number of candidates omitted the origin point. Some graphs were not labelled, as required. The majority of candidates drew smooth line graphs while other candidates joined the points with straight lines drawn with a ruler; these lines did not gain credit.

(c) This question was well answered with Experiment 1 being correctly identified as having the fastest rate of reaction. References to the acid in Experiment 1 being more reactive were not credited.

(d) Most candidates found the volume of gas produced after 30 seconds in Experiment 1 from the graph although a number of candidates misread the scale on the *x*-axis. The average rate was then generally correctly calculated with most answers including the correct units.

(e) Better-performing candidates understood that all the magnesium had reacted. However many responses showed a lack of knowledge and understanding and concluded that all the reactants or all the solution had reacted.

(f) Many candidates realised that using magnesium powder would result in the rate of the reaction increasing because of the larger surface area. Some answers incorrectly referred to the smaller surface area of the powder.

(g) Mistaken references to the accuracy or precision of a measuring cylinder were common. Vague references to the amount of liquid that the cylinder could hold were also seen.

Many candidates thought that a disadvantage of using a measuring cylinder was that liquid would be left in the bottom of the cylinder, but did not recognise that measuring cylinders are less accurate.

(h) The most common improvements given were to use a pipette / burette instead of a measuring cylinder or to take measurements over shorter time intervals.

Question 3

(a) Chlorine was correctly identified by many candidates. Ammonia was a common incorrect answer.

(b)(i) Candidates generally realised that **test 2** produced a red-brown precipitate because iron(III) ions were present but were unable to identify that the precipitate was iron(III) hydroxide. Many answers incorrectly gave the formation of iron(III) oxide or various other iron(III) salts.

(ii) Only the better-performing candidates gained full credit for the observation that a green precipitate would form. References to colour changes, bubbles or fizzing were recorded.

(c) This question was well answered with most candidates naming the gas as oxygen.

(d) The presence of a catalyst, transition element compound, manganese(II) oxide or copper(II) oxide were all identified by better-performing candidates. Chlorides, iodides and carbonates were common incorrect responses.

Question 4

There were many very strong answers, often using methods that involved reduction of tin oxide or the displacement of tin using more reactive metals. However, some candidates were still clearly not prepared for this type of question.

Many candidates gained partial credit for crushing the lump of cassiterite with a pestle and mortar or showing how a percentage calculation could be done. A lack of knowledge and understanding was often evident with answers mentioning adding water to the cassiterite or heating it, and then electrolysing the solution or molten compound. Some answers suggested heating or adding acid to the cassiterite and then filtering off the tin; such answers showed a lack of knowledge and understanding. Some candidates did not use the information in the question that tin is similar in reactivity to iron.