CHEMISTRY

Paper 0620/11
Multiple Choice (Core)

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

General comments

Some candidates performed reasonably well on this paper.

Candidates found **Question 9** to be of lower demand.

Questions 6, **18**, **19**, **23**, **24** and **38** proved to be more challenging to candidates.

Questions 10, **11**, **22**, **23**, **24** and **39** had approximately equal numbers of candidates selecting each response. This indicates that candidates were unsure of the correct answer.

Comments on specific questions

The following responses were popular incorrect answers to the questions listed:

Question 2

Response **A** – Candidates did not understand that at the same temperature the particles would have the same speed. This response was more popular than the correct one.

Question 6

Response **C** – Candidates did not take into account that the substance had to be soluble in water. This response was more popular than the correct one.

Question 18

Response **B** – Candidates did not realise that adding an excess of sodium hydroxide would produce an alkaline solution. This answer was more popular than the correct one.

Question 19

Response **B** – Candidates selected **B** on the basis of the gas test given. These candidates had not read the question carefully, which asked for the identity of solid Q. This response was more popular than the correct one.

Question 27

Response **B** – Candidates were not familiar with the metal uses given in the syllabus.

Question 29

Response **C** – Candidates did not appreciate the importance of the oil layer.

Question 33

Response **A** – Candidates did not read the question carefully, missing the word ‘complete’ when selecting this response.

Question 38

Response **B** – Candidates did not know that the reaction between steam and ethene requires a catalyst. This response was more popular than the correct one.

Question 40

Response **B** – Candidates missed the word ‘natural’ when selecting this response.

CHEMISTRY

Paper 0620/12
Multiple Choice (Core)

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

General comments

Candidates performed reasonably well on this paper.

Candidates found **Questions 1**, **5**, **25** and **37** to be of lower demand.

Questions 13, **15** and **20** proved to be more challenging to candidates.

Questions 13, **23**, **26** and **39** had approximately equal numbers of candidates selecting each response. This indicates that candidates were unsure of the correct answer.

Comments on specific questions

The following responses were popular incorrect answers to the questions listed:

Question 2

Response **B** – Candidates only considered the gas without reading the other alternatives.

Question 15

Response **C** – Candidates were not familiar with potassium manganate(VII). This response was more popular than the correct one.

Question 18

Response **A** – Candidates did not realise that the excess carbonate had to be removed before evaporation.

Question 20

Responses **A** and **D** – Both of these responses were more popular than the correct one. Candidates did not know the colour changes for methyl orange.

Question 22

Response **D** – Candidates did not know that a hydroxide is produced from Group **I** metals. This response was more popular than the correct one.

Question 30

Response **C** – Candidates thought that acids have a high pH.

Question 33

Response **A** – Candidates did not read the question carefully, missing the word 'complete' when selecting this response.

Question 38

Response **B** – Candidates did not know that the reaction between steam and ethene requires a catalyst. This response was more popular than the correct one.

Question 40

Response **B** – Candidates missed the word 'natural' when answering this question.

CHEMISTRY

Paper 0620/13
Multiple Choice (Core)

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

General comments

Candidates performed reasonably well on this paper.

Candidates found **Questions 1**, **2**, and **27** to be of lower demand.

Questions 10 and **19** proved to be more challenging to candidates.

Questions 10, **11**, **17**, **23**, **24**, **30**, **31** and **34** had approximately equal numbers of candidates selecting each response. This indicates that candidates were unsure of the correct answer.

Comments on specific questions

The following responses were popular incorrect answers to the questions listed:

Question 3

Response **B** – Candidates seemed to be unsure of the effect on melting point.

Question 5

Response **B** – Candidates knew isotopes had something to do with the nucleus but were not sure what.

Question 6

Response **D** – Candidates knew it was ionic but mistakenly thought ionic compounds would conduct in the solid state.

Question 19

Response **C** – Candidates were reluctant to choose all four reactions.

Question 21

Response **A** – Candidates confused nucleon number with proton number.

Question 22

Response **D** – Candidates did not realise that Group **I** metals form hydroxides, not oxides in water.

Question 33

Response **A** – Candidates did not read the question carefully, missing the word 'complete' when selecting this response.

Question 36

Response **D** – Candidates knew ethene had a double bond but were unsure about the other compound.

Question 38

Response **B** – Candidates did not know that the reaction between steam and ethene requires a catalyst. This response was more popular than the correct one.

Question 40

Response **C** – Candidates saw the word ethene and did not understand that poly(ethene) is saturated.

CHEMISTRY

Paper 0620/21
Multiple Choice (Extended)

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

General comments

Candidates performed reasonably well on this paper.

Candidates found **Questions 3**, **9**, **17**, **30**, **32** and **40** proved to be of lower demand.

Comments on specific questions

The following responses were popular incorrect answers to the questions listed:

Question 1

Response **A** – Candidates were not aware of the reason why the particles move.

Question 6

Response **A** – Candidates recognised a true description of bonding but did not consider all alternatives.

Question 13

Response **A** – Candidates added the two quantities, not fully understanding the requirements for determining energy change from an energy level diagram.

Question 15

Response **B** – Candidates did not realise that the addition of sodium hydroxide would remove hydrochloric acid.

Question 18

Response **B** – Candidates saw the test for ammonia, without reading the question carefully, as it was the identify of solid Q that was required. This response was more popular than the correct one. Candidates should be encouraged to read the whole question.

Question 21

Response **D** – Candidates did not realise that Group **I** metals form hydroxides, not oxides in water.

Question 23

Response **D** – Candidates realised that R had single atoms (inert gas) but did not identify helium.

Question 24

Response **A** – Candidates who selected this response had not considered all of the other options. Candidates should be encouraged to read the whole question.

Question 33

Response **C** – Candidates missed the word ‘weak’ when selecting this response. This response was more popular than the correct one.

Question 37

Responses **B** and **C** were both more popular than the correct response. Candidates did not know that both reactions require a catalyst.

CHEMISTRY

Paper 0620/22
Multiple Choice (Extended)

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

General comments

Candidates performed well on this paper.

Candidates found **Questions 1**, **3**, **4**, **9**, **14**, **26**, **28**, **30**, **32**, **36**, **38** and **40** to be of lower demand.

Comments on specific questions

The following responses were popular incorrect answers to the questions listed:

Question 7

Response **A** – Candidates chose the lowest number. This response was more popular than the correct one.

Question 11

Response **D** – Candidates knew the correct direction for the ions but did not look at the polarity of the power supply.

Question 16

Response **B** – Candidates were confused about the meaning of the term *oxidising agent*.

Question 19

Candidates found this question challenging. All responses were selected by a significant number of candidates, indicating that many were unsure of the correct answer.

Question 25

Response **C** – Candidates chose the wrong direction for the reactivity change.

Question 33

Response **C** – Candidates missed the word 'weak' when selecting this response. This response was more popular than the correct one.

CHEMISTRY

Paper 0620/23
Multiple Choice (Extended)

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

General comments

Candidates performed well on this paper.

Candidates found **Questions 3**, **4**, **7**, **8**, **9**, **12**, **14**, **16**, **25**, **26**, **28**, **30**, **31**, **32**, **36**, **38**, **39** and **40** to be of lower demand.

Comments on specific questions

The following responses were popular incorrect answers to the questions listed:

Question 11

Response **D** – Candidates knew the correct direction for the ions but did not look at the polarity of the power supply.

Question 13

Response **A** – Candidates added the two quantities, not fully understanding the requirements for determining energy change from an energy level diagram.

Question 19

Response **D** – Candidates did not realise that the addition of a base to an ammonium salt would liberate ammonia.

Question 21

Response **D** – Candidates did not realise that Group **I** metals form hydroxides, not oxides in water.

Question 23

Response **D** – Candidates realised that R had single atoms (inert gas) but did not identify helium.

Question 33

Response **C** – Candidates missed the word ‘weak’ when selecting this response. This response was more popular than the correct one.

Question 35

Response **C** – Candidates did not know the substitution reaction of methane.

CHEMISTRY

Paper 0620/31
Theory (Core)

Key messages

Many candidates need more practice in interpreting the stem of a question and in extracting information from graphs with the required degree of accuracy.

Many candidates need to write with greater precision and to include key terms from the syllabus, which will lead to a good answer.

Many candidates need more practice in questions involving qualitative analysis.

Some candidates need further practice in answering free response questions.

General comments

Many candidates tackled this paper well, showing a good knowledge of core chemistry. Nearly all candidates were entered at the appropriate level. The standard of English was generally good. Most candidates attempted all parts of each question. The exceptions were **Questions 4(a)(ii)**, **4(b)**, **5(c)(ii)**, **6(b)(i)**, **8(a)(i)**, **8(b)(ii)** and **(8)(c)(i)**, where a significant number of candidates did not respond.

A significant proportion of the candidates did not appear to read the stem of the question and information in tables carefully enough. For example, in **Question 1(a)(v)** many candidates did not appear to take note that the electronic structures were atoms and not ions. In **Question 2(a)(i)** some candidates gave the ion with the greatest concentration rather than the lowest concentration. In **Question 2(a)(iv)** many candidates did not take note of the word compound in the stem of the question and gave the names of ions or elements. In **Question 3(d)** many candidates did not refer to the equation as requested and just gave a definition of reduction. In **Question 5(b)(ii)** some candidates wrote about gases given off, electrons being gained or conduction.

In several questions, many candidates did not appear to read the instructions and gave explanations when observations were asked for. For example, in **Question 3(b)** many candidates wrote about copper sulfate losing water or copper sulfate going back to being anhydrous rather than writing about a colourless liquid formed or the copper sulfate turning white.

Better performing candidates often underline or circle the key parts of the stem of the question and return to these to check that the question has been correctly answered.

Many candidates need more practice at reading values from a graph. In **Question 4(d)(ii)** and **Question 4(a)(iii)** many candidates did not give precise enough readings. In **Question 5(a)(ii)** many made simple errors in reading the values on the *y*-axis of the graph.

Candidates should ensure that they know the meaning of key terms used in the syllabus and to include these key terms with greater precision in their answers. For example, in **Question 3(a)(ii)** many candidates wrote statements that were too vague or incomplete to be credited, e.g. 'the water goes into the condenser', with no mention of going from vapour to liquid. In **Question 3(b)** those who did give observations often wrote statements that were too vague to be awarded credit, e.g. 'copper sulfate changes colour'. Candidates should carefully revise the definitions of scientific terms which appear in the syllabus. For example, in **Question 4(c)** many candidates confused elements and compounds. In **Question 8(a)(ii)** few candidates defined the term *endothermic* with the precision required.

Many candidates need more practice in questions involving qualitative tests. For example, very few candidates knew the test for potassium in **Question 2(b)** or the test for an unsaturated hydrocarbon in **Question 4(a)(ii)**.

Many candidates need more practice in answering questions involving extended answers such as **Question 3(a)(ii)** (how distillation separates copper sulfate from water) and **5(a)(ii)** (separation and motion of particles in a liquid and a gas). Candidates should give well-reasoned and step-by-step answers. In **Question 3(a)** better performing candidates considered the differences in boiling points between copper sulfate and water and gave a precise explanation of steam turning to liquid water in the condenser. In **Question 5(a)(ii)** better answers had set out each part of the response clearly, e.g. separation – close together, motion – sliding over each other.

Questions involving general chemistry, were tackled well by some candidates. Many candidates were able to balance simple equations and extract relevant information from tables of data. Others need more practice in naming compounds and writing formulae, especially formulae of organic functional groups and the formulae of molecules. Many candidates also need more practice in deducing the products of electrolysis from a given electrolyte and in understanding the difference in physical properties of metals, simple molecules and ionic structures.

Comments on specific questions

Question 1

This was the best answered question on the paper. Most candidates identified the correct electronic structures in **(a)(ii)**, **(a)(iii)** and **(a)(iv)**. Fewer recognised the electronic structures of a metal in **(a)(i)** or the atoms, which form an ion with a single negative charge in **(a)(v)**. Many candidates deduced the numbers of at least two of the sub-atomic particles in **(b)**.

(a) (i) Some candidates identified **C** as being a metal. The most common error was to suggest **B**, which has a complete shell of electrons.

(ii) The majority of the candidates correctly identified **C** as having a proton number of 13. The most common incorrect answer was **E**, perhaps chosen by ignoring the inner electron shell.

(iii) Many candidates correctly identified the atom of phosphorus. The most common error was to choose structure **A,** which had seven electrons in the outer shell rather than five.

(iv) The majority of the candidates correctly identified structure **D** as having two shells of electrons.

(v) Some candidates realised that structure **A** (chlorine) forms a stable ion with a single negative charge. The most common error was to misread the stem of the question and suggest structure **B**, a noble gas structure that is an atom according to the stem of the question and not an ion.

(b) Some candidates were able to deduce the numbers of at least two of the sub-atomic particles. The most common correct answer was 8 for the number of neutrons. A considerable number of candidates suggested 14 protons for carbon and 40 protons for the potassium ion by selecting the mass number rather than the atomic number. Few candidates deduced the number of electrons in the K^+ ion. Most ignored the fact that K^+ is an ion and gave an answer of 19. A few gave the answer 20 by adding electrons rather than removing them.

Question 2

Many candidates were able to extract relevant information from the table in **(a)(i)** and identify carbohydrates as being present in foods in **(c)**. Some candidates were able to do the calculations in **(a)(iii)** correctly. Others complicated matters by multiplying or dividing by 1000. A minority of candidates described a suitable test for potassium in **(b)**. Some candidates identified the alcohol functional group in **(d)(i)**. Fewer gave the correct formula for compound **S** in **(d)(ii)**.

(a) (i) Nearly all the candidates recognised that potassium was the positive ion with the lowest concentration. The most common incorrect answer was the sodium ion, the positive ion with the greatest concentration, an error arising from misreading the stem of the question

(ii) Many candidates named potassium chloride correctly. Others misread the table and chose magnesium chloride. A significant number suggested potassium chlorine. In order to improve their marks when naming compounds, candidates should be encouraged to use the pattern that in a compound of a metal with a non-metal, the non-metal changes from –ine to –ide.

(iii) Many candidates gave the correct answer, showing the steps in their calculation. Others complicated matters by either trying to do mole calculations or multiplying or dividing by 1000. The most common error was to divide 0.16 by 200, leading to the incorrect answer of 0.008. The inverse of this was also seen. Another common incorrect answer was 0.8, derived from $1000 \cdot \frac{0.16}{200}$. A few candidates truncated their answers to 0.03.

(iv) Some candidates selected the two ions present in the greatest concentrations. Others appeared not to read the word 'compound' in the stem of the question and suggested sodium (alone) or chloride (alone). Sodium chlorine was also seen, indicating that many candidates need more practice in naming compounds. A significant number of candidates suggested substances which were not in the table, e.g. diamond.

(b) Those candidates who realised that Group I metals produce characteristic flame colours often obtained both marks for the lilac colour of the potassium flame. The most common errors were to suggest yellow or red. A majority of the candidates suggested incorrectly to add sodium hydroxide or ammonia and noted the colour of the precipitate. Others suggested adding potassium to water but made no mention of a flame.

(c) Nearly all the candidates identified carbohydrates as being present in foods. The most common error was to suggest hematite.

(d) (i) Some candidates recognised the alcohol functional group. The most common error was to circle the COOH group.

(ii) Some candidates wrote the correct formula. Others counted the number of atoms but did not write a proper chemical formula, e.g. C3 + H7 + O3 + N. Other candidates wrote a formula which was part structural, e.g. $C_3NO_2H_6OH$. Other common errors included miscounting the hydrogen atoms giving $C_3H_5NO_3$ or omitting the nitrogen atom giving $C_3H_5O_3$. A few candidates disadvantaged themselves by writing the numbers.

Question 3

This was the least well answered question on the paper. The completion of the equation in **(c)(i)** was generally answered well by most candidates. Some candidates were able to name the condenser in **(a)(i)** and complete the word equation in **(e)**. In **(a)(ii)** many candidates gave conflicting, imprecise or vague answers when describing the separation of water from copper(II) sulfate. Very few candidates gave suitable observations in **(b)**. In **(c)(ii)** many candidates did not give a suitable practical method for separating copper oxide from a solution of copper sulfate. In **(d)** many did not refer to the equation.

(a) (i) Some candidates recognised the condenser or gave words closely related, e.g. 'condensation tube'. Others suggested pipette, measuring tube or cooling tube.

(ii) The best answers mentioned in order heating the aqueous copper sulfate, turning water into steam but leaving the copper sulfate in the flask and condensing the steam back to liquid water in the condenser. Many candidates referenced heating the solution of copper sulfate and knew that water turned into steam or evaporated. Fewer specified that copper sulfate remained in the distillation flask or that water vapour or steam was cooled in the condenser to form liquid water or that 'steam goes to water in the condenser'. Many candidates wrote statements that were too vague or incomplete to be credited, e.g. 'the water goes into the condenser', with no mention of going from vapour to liquid or 'the particles of water are heated and go to the condenser to be made water again', with no mention of vapour. A minority of candidates mentioned that copper sulfate remained in the flask and hardly any mentioned the difference in the boiling points of copper sulfate and water. Some mentioned the difference in melting points, which was not accepted. A considerable number of candidates thought that copper sulfate would vaporise after the water and so reached the condenser later. Many candidates did not order their answers sufficiently, e.g. writing about condensation before heating and this led to conflicting statements.
Better performing candidates ensured that they wrote their answers in a sensible order, using bullet points if necessary and re-reading their answers to ensure there were no conflicting statements.

(b) Many candidates did not give observations and wrote statements such as 'the water separates from the copper sulfate', 'the water evaporates' or 'the copper sulfate becomes anhydrous'. Those who did give observations often wrote statements that were too vague to be awarded credit, e.g. 'copper sulfate changes colour'. Candidates should ensure that they know the difference between observations and explanations and to write with greater precision, e.g. 'copper sulfate turns white' rather than 'it changes colour'.

(c) (i) Many candidates recognised that water was formed. The most common errors were H_2 or O_2. A few candidates did not realise that the completion of a chemical equation should involve a formula rather than a name.

(ii) Some candidates realised that filtration could be used to separate a solid from a solution. Many candidates did not realise that copper sulfate in the solution would not evaporate when heated and gave the incorrect answer 'distillation'. Others suggested crystallisation or reduction.

(d) Many candidates did not respond to this question with the precision required and gave answers that did not refer to the equation. The best answers referred to the loss of oxygen from the copper oxide, rather than just loss of oxygen, which does not refer to the equation. Common errors included the suggestion that oxygen is removed from an element or that oxygen is reduced. Many gave a non-chemical answer, e.g. 'getting smaller' or 'formula reduced'. Although other definitions were accepted, many candidates gave incorrect answers such as 'copper oxide loses electrons' or 'oxidation number of copper oxide gets less'. Candidates should use the definitions required for the core paper.

(e) Many candidates completed the word equation correctly. Most candidates correctly identified copper nitrate and water. Some suggested hydrogen instead of water. Others suggested copper nitroxide instead of copper nitrate. Fewer candidates identified nitrogen dioxide. Other common errors included nitric acid, nitrate or nitrate dioxide.

Question 4

Parts **(a)(i)**, **(c)** and **(d)(iii)** were answered well by many candidates. Many did not know the test for an unsaturated compound in **(a)(ii)** and many candidates did not respond to this part. Better performing candidates could draw the structure of the carboxylic acid functional group in **(b)** and describe the pH changes fully in **(d)(i)**.

(a) (i) Many candidates identified the C=C bond as being responsible for unsaturation. The most common error was to refer to either the COOH or CH_3 group. Others wrote vague statements about carbon atoms or carbon bonds without reference to the double bond, e.g. 'there are two carbon bonds'.

(ii) Few candidates knew the test for unsaturation. A wide variety of incorrect test reagents was seen including litmus, flame test, copper sulfate and hydrogen. A minority of the candidates knew the correct colour change when aqueous bromine reacts with an unsaturated compound. A significant number of candidates did not respond to this question.

(b) A minority of the candidates drew the structure of the carboxylic acid functional group showing all of the atoms and all of the bonds. Common errors included drawing alcohols or aldehydes instead of carboxylic acids or drawing structures with double bonds between carbon and hydrogen atoms. A significant number of candidates drew the functional group with a C–H–O or C=O–H. Others drew structures with only single bonds. Candidates should practice drawing both molecular and displayed formulae for the limited number of organic compounds required for the core paper. A significant number of candidates did not respond to this question.

(c) Some candidates selected all three correct words. Others selected only one of the words correctly. The most common errors were element instead of compound, physical or compounds instead of chemical and chemical instead of functional. Candidates should learn the definitions for the terms given in the syllabus with the accuracy required so that terms such as *elements* and *compounds* do not get confused.

(d) (i) Many candidates realised that the pH increased as more sodium hydroxide was added. The best answers focussed on the rate of the change, i.e. slowly increasing at first then rapidly increasing when 23 cm^3 of alkali had been added. Many candidates did not answer precisely enough and just referred to 'change in pH' instead of 'pH increases'. Better responses stated the direction of the change.

(ii) Some candidates deduced the correct pH. Others misread the graph and suggested pH 2.5 or pH 2.2. Others misread the stem of the question and gave pH 13, which is near the final value where there is excess sodium hydroxide.

(iii) A majority of the candidates deduced the volume correctly. The most common errors arose from a misreading of the graph 20, 20.5 or 20.6 cm^3 being common incorrect answers.

Question 5

Some candidates responded well to this question, especially in **(a)(i)** and **(b)(i)**. Some candidates gave well-argued responses to the extended answer question in **(a)(ii)**. Others wrote answers that were too vague. In **(b)(ii)** many candidates wrote the name of an element or ion instead of the name of a compound. A minority of the candidates gave good answers to the electrolysis question in **(c)**. Most candidates need more practice in questions involving naming the products of electrolysis.

(a) (i) Most candidates were able to give the correct names for the changes of state. The most common errors were to suggest boiling, liquidation or sublimation instead of melting, and vaporisation, melting or sublimation for condensing.

(ii) Some candidates gave clear descriptions of the separation and motion of the particles in a liquid and in a vapour. Others wrote unnecessarily about intermolecular forces, which is not required for the core paper. The best answers made it clear that the separation was close together in the liquid and far apart in the vapour and that the motion in liquids was restricted and that the motion in the gas was rapid and random. Many responses did not make it clear whether it was separation or motion that was being discussed. Other candidates wrote about the bulk properties of liquids and gases. A considerable number of candidates contradicted themselves, e.g. 'particles are close to each other and slightly far apart'. Candidates should be encouraged to set out each part of their answer clearly, e.g. separation – close together, motion – sliding over each other.

(b) (i) A majority of the candidates balanced the equation correctly. The most common error was to balance the water incorrectly with $3H_2O$.

(ii) Many candidates wrote lithium alone or hydroxide alone and not the full name of the product, lithium hydroxide. Candidates should be aware that the name of the product should be the full name. Other common errors included 'alkane', possibly because of the similarity to alkali and lithium oxide.

(c) (i) Some candidates predicted the products at the electrodes correctly. Others gave the correct products at the incorrect electrodes. A considerable number of candidates disadvantaged themselves by suggesting that the products were ions. Others did not seem to understand the meaning of the word ‘product’ and gave answers such as ‘anode and cathode’ or ‘movement of positive ions and movement of negative ions’. A few candidates suggested products such as phosphorus, which bore no relationship to the ions in the electrolyte. The most common error was to suggest sulfur or sulfur dioxide at the anode.

(ii) Very few candidates gave a suitable observation at the electrodes. The best answers referred to effervescence or bubbles. Some suggested that ‘a gas is formed’, which is not an observation. Other incorrect answers included ‘electrons are gained’ or ‘conducts’. Some candidates suggested that ‘the bulb lights’ even though there was no bulb in the diagram. Candidates should understand the difference between observations and conclusions. A significant number of candidates did not respond to this question.

(iii) Many candidates did not realise that both magnesium and graphite conduct electricity and so suggested that graphite was a better conductor than magnesium or that graphite conducted but magnesium did not. The best answers suggested that graphite is inert whilst magnesium can react with the electrolyte. Others gave more vague answers, suggesting that graphite is less reactive than magnesium. A considerable number of candidates just referred to the structure of graphite or the fact that graphite does not dissolve without mentioning lack of reactivity.

Question 6

Most candidates gave good answers to **(a)(i)** (covalent structure), **(b)(i)** (equation) and **(c)** (fertilisers). Many candidates did not appreciate in **(b)(ii)** that non-metal oxides are acidic.

(a) (i) Most candidates realised that phosphorus and carbon were covalently bonded. The most common error was to suggest the ionic structure, **T**.

(ii) Many candidates identified the structures that conducted electricity. The most common error was to suggest the ionic structure, **T**, which only conducts when molten or in aqueous solution.

(iii) Some candidates identified phosphorus as having a low melting point. The most common errors were to suggest the covalent structure, **R** or the ionic structure **T**.

(iv) Some candidates realised that **T** was soluble in water. The most common error was to suggest zinc.

(b) (i) A majority of the candidates balanced the equation correctly.

(ii) The best answers suggested that phosphorus(V) oxide is an acidic oxide and related this to the fact that phosphorus is a non-metal rather than relating it to the position in the Periodic Table. A minority of candidates suggested that phosphorus(V) oxide is an acidic oxide but many of those who appreciated this did not give an appropriate explanation. Others gave a definition of an acid or referred vaguely to an acid. A considerable number of candidates suggested ‘basic’. A few suggested ‘amphoteric’ even though there was no need to know this term for the core paper. A significant number of candidates did not respond to this question.

(c) (i) Many candidates knew that nitrates are found in many fertilisers. The most common error was to suggest the fluoride ion.

(ii) Some candidates understood why farmers add fertilisers to the soil and gave good answers such as ‘to increase the amount of nutrients for increased plant growth’. A significant number wrote answers such as ‘it gives nutrients to the soil’ rather than focussing on the plants. Others wrote answers that were not precise enough, e.g. ‘they benefit the plant’ or ‘gives them the nutrients they need’. A significant number of candidates thought that fertilisers killed bacteria.

Question 7

Many candidates scored reasonably well in this question, especially in **(a)(ii)** and **(b)**. In **(a)(i)** few candidates referred to a gas being produced. In **(a)(iii)** many candidates drew a steeper initial gradient; fewer took note of the fact that the acid was in excess.

(a) (i) The best answers suggested that the loss in mass was due to a gas being released, specifically carbon dioxide. The majority of the candidates suggested, incorrectly, that either 'calcium carbonate dissolves' or that 'hydrochloric acid evaporates'.

(ii) Many candidates calculated the loss in mass correctly. Others misread the graph and gave incorrect answers, which differed by an integer, e.g. 1.2 and 3.2.

(iii) Many candidates drew a steeper initial gradient. A minority realised that the acid was in excess in both the dilute and concentrated acid and so all the calcium carbonate would be used up and the final volume of gas would be the same for both concentrations. Others drew the line below the one already shown on the graph. In this type of graphical question, candidates should make sure that they check whether the acid or the other reactant is in excess.

(iv) Some candidates realised that the rate of reaction increases with temperature. Others thought that the rate increased with time and suggested that the fastest rate occurred at 20°C and the slowest occurred at 40°C. In questions involving rate of reaction, candidates should realise that the slower the rate, the greater the time taken and the faster the rate, the less the time taken.

(b) Some candidates knew the iron extraction process well; many others made at least two errors. The most common errors were 'bauxite' instead of hematite, 'monoxide' instead of dioxide and 'silicon' instead of slag. The distractor 'tetrachloride' was not infrequently seen in all three spaces.

Question 8

Many candidates gave good answers to **(a)(i)** (relative formula mass) and **(a)(iii)** (neutralisation reaction). The meaning of the term *endothermi*c in **(a)(ii)** was not well known. In **(b)** some candidates knew the percentage of oxygen in the air and could interpret an energy level diagram. Fewer were able to write the word equation in **(b)(ii)**. In **(c)** some candidates knew about the properties of argon; fewer suggested a correct use of this gas.

(a) (i) Many candidates calculated the relative formula mass of sodium carbonate correctly. The most common errors involved a misunderstanding of the meaning of the subscripted numbers in a chemical formula. Common errors included 83, only one sodium atom used in the calculation; 51, adding 23 + 12 + 16 with no multiplication; or 74, only one oxygen atom used in the calculation. Many candidates need to revise how to deduce the number of atoms in a chemical formula. A significant number of candidates did not respond to this question.

(ii) Some candidates gave good answers, which included the idea of heat being absorbed. Others referred to bond breaking and bond making or wrote about energy being absorbed but did not refer to the essential word 'heat'.

(iii) Many candidates identified the neutralisation reaction correctly. The most common error was to suggest 'addition'. A few chose 'oxidation'. Candidates should be aware that lime is basic and so reacts with acids by neutralisation.

(b) (i) Many candidates knew that oxygen forms 21% of dry air. A wide range of incorrect answers were seen including helium, carbon monoxide, carbon dioxide and hydrogen. This suggests that some candidates had not committed the percentage composition of the common gases in the air to memory.

(ii) A minority of the candidates wrote the correct word equation for the complete combustion of carbon. Common errors included carbon monoxide as a product and the omission of oxygen as a reactant. Others suggested that heat was a reactant or a product. Candidates should be advised not to write heat in these positions but to include it above the arrow or add it in brackets afterwards but not with a + sign. A number of candidates wrote symbol equations, which were often incorrect. Many candidates need to practise writing simple word equations and distinguish word equations from chemical symbol equations. A significant number of candidates did not respond to this question.

(iii) Many candidates added the words ‘reactants’ and ‘product’ to the energy level diagram in the correct places. The most common error was to reverse the positions of these words. Some candidates placed the word ‘reactants’ next to the arrow. A significant number of candidates did not respond to this question.

(c) (i) A minority of the candidates gave a suitable use for argon. The best answers referred to argon being used as an inert gas in lamps. Others wrote answers that were imprecise or inaccurate, e.g. ‘used in the filaments of lamps’, ‘in neon lamps’ or ‘used in extracting chemicals’. A significant number of candidates wrote answers that were too vague, e.g. ‘to eliminate impurities’ or ‘in industry’. A significant number of candidates did not respond to this question.

(ii) Many candidates selected the two correct statements about argon. The most common incorrect answer was ‘argon is a greenhouse gas’. A significant number of candidates suggested that ‘argon is diatomic’.

CHEMISTRY

Paper 0620/32
Theory (Core)

Key messages

Many candidates need more practice in interpreting the stem of a question and using information in tables.

Many candidates need to write with greater precision and to include key terms, which will lead to a good answer.

Many candidates need more practice in questions involving qualitative analysis.

Some candidates need further practice in answering free response questions.

General comments

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

A significant proportion of the candidates did not appear to read the stem of the question and information in tables carefully enough. For example, in **Question 3(a)(i)** many candidates did not appear to take note that both copper and selenium were insoluble in water. In **Question 3(a)(ii)** some candidates did not show all of the bonds in ethanol. In **Question 7(c)** many candidates did not heed the words 'characteristic of metals' and gave properties that were typical of transition metals or Group I metals.

In several questions that required observations, candidates gave explanations instead. For example, in **Question 5(b)(iii)** many candidates wrote about substances formed rather than 'brown vapour formed'. In **Question 5(c)(iii)** some gave the name silver bromide rather than 'cream precipitate'.

Better performing candidates tended to underline or circle the key parts of the stem of the question and return to these to check that the question has been correctly answered.

Candidates should ensure they know the meaning of key terms used in the syllabus and use these with greater precision in their answers. For example, in **Question 2(a)(iv)** many referred to hydrocarbonate rather than taking the name of the negative ion, hydrogencarbonate, from the table. In **Question 3(a)** many candidates just wrote about washing and drying rather than qualifying these words further, e.g. 'wash with water' or 'leave to dry on some filter paper'. In **Question 5(b)(i)** many candidates wrote the words anode and electrolyte but did not draw a line to show which part of the apparatus applied to these words. In **Question 7(d)(i)** some candidates answered the question about alloys by suggesting that they are mixtures of elements rather than mixture of a metal with another element.

Many candidates need more practice in questions involving qualitative tests. For example, very few candidates knew the test for calcium in **Question 2(b)**, the test for an unsaturated hydrocarbon in **Question 4(a)(ii)**) or the test for bromide ions in **Question 5(c)(iii)**.

Many candidates need more practice in answering questions involving extended answers such as **Question 3(a)(i)**, the separation of copper and selenium and **Question 5(a)**, the arrangement and motion of particles in a liquid and a gas. In **Question 3(a)** better performing candidates gave well-reasoned and step-by-step answers, which considered the differences in solubility. In **Question 5(a)** these candidates set out each part of their answer clearly, e.g. arrangement – random, motion – sliding over each other.

Questions involving general chemistry, were often tackled well by candidates. Many candidates were able to balance simple chemical equations and extract relevant information from tables of data. Others need more practice in naming compounds, writing formulae, understanding how to deduce the products of electrolysis from a given electrolyte and in understanding the reactions of halogens with halide ions.

Comments on specific questions

Question 1

This was one of the best answered questions on the paper. Most candidates identified the correct electronic structures in **(a)(i)**, **(a)(iii)** and **(a)(iv)**. Fewer recognised the electronic structures of a reactive non-metal in **(a)(ii)** or the atoms which form an ion with a single positive charge in **(a)(v)**. Many candidates deduced the numbers of at least two of the sub-atomic particles in **(b)**.

(a) (i) Many candidates identified the Group VIII element. The most common error was to suggest structure **E** (two electrons in the outer shell).

(ii) Some candidates correctly identified an atom of a reactive non-metal. The most common error was to suggest structure **D** (beryllium), a reactive metal. This suggests that some candidates did not read the question carefully and had not noted the prefix non-(metal).

(iii) Nearly all candidates identified the atom with proton number 11. A few candidates suggested structure **A** (neon).

(iv) Many candidates correctly identified sodium. The most common incorrect answer was **E** (calcium), which has three complete electron shells rather than three shells.

(v) Some candidates realised that a sodium ion has a single positive charge. The most common errors were to suggest either **C** fluorine, which forms an ion with a single negative charge or **D** beryllium, which forms an ion with two negative charges. Candidates should realise that positive ions are formed by electron loss and not electron gain.

(b) Many candidates were able to deduce the numbers of at least two of the sub-atomic particles. The most common correct answer was 8 for the number of neutrons. Many candidates gave the correct number of protons. The most common error being to suggest that nitrogen has 8 protons, the same as the number of neutrons in the isotope. A considerable number of candidates suggested 15 protons for nitrogen and 52 protons for the chromium ion by selecting the mass number rather than the atomic number. Few candidates deduced the number of electrons in the Cr^{2+} ion. Most ignored the fact that Cr^{2+} is an ion and gave an answer of 24. A few gave the answer 26 by adding electrons rather than removing them.

Question 2

Many candidates were able to extract relevant information from the table in **(a)(i)** and identify the carboxylic acid group in **(c)(i)**. Some candidates were able to do the calculations in **(a)** correctly. Others complicated matters by either trying to do mole calculations or multiplying or dividing by 1000. A minority of candidates described suitable observations for the qualitative test for calcium ions in **(b)**. A greater number were successful in completing the sentences in **(d)**.

(a) (i) Most candidates gave the correct answer. The most common error arose from a misreading of the question and suggesting potassium ions, which have the highest concentration of positive ions rather than negative ions. Chloride was the second most common error.

(ii) A minority of the candidates gave the correct answer, showing the steps in their calculation. Others complicated matters by either trying to do mole calculations or multiplying or dividing by 1000. Another common error was to divide 540 by 250, leading to an incorrect answer of 2.16. The inverse of this was also seen, i.e. $\frac{250}{540} = 0.46$.

(iii) Some candidates selected the positive ions and added these values together to get the correct answer. Others did not heed the word 'positive' in the stem of the question and gave the value of 1707 mg for the total mass of ions. Some tried to do concentration calculations for particular ions, often using the value of 250 cm^3 from **(a)(ii)**.

(iv) A minority of the candidates named sodium hydrogencarbonate correctly. Many did not use the information in the table and suggested either sodium carbonate or sodium hydrocarbonate. A significant number suggested two names; the most popular being sodium carbonate + hydrogen. When naming unfamiliar compounds, candidates should be encouraged to use all the information in the question stem, in this case in the table.

(b) A minority of the candidates scored both marks. A greater number of candidates knew the effect of aqueous sodium hydroxide on a solution containing calcium ions. Some did not gain the mark because they contradicted themselves by suggesting that the white precipitate dissolves. Good answers describing the effect of aqueous ammonia included 'a little white precipitate', 'no precipitate' and 'colourless solution formed'. Common errors included vague answers such as 'colour changes' or 'goes misty white'. A considerable number of candidates mentioned bubbles or did not give observations. When answering questions about qualitative analysis, candidates should be advised to state whether a precipitate or a solution is formed.

(c) (i) Many candidates identified the carboxylic acid group as COOH. The most common errors were CH_3, OH or C–COOH. Candidates should be reminded that the carbon atom next to the COOH group is not part of the functional group.

(ii) Some candidates wrote the correct formula. Others counted the number of atoms but did not write a proper chemical formula, e.g. C3 + H6 + O3. Some candidates wrote a formula that was part structural, e.g. $CH_3CH_3CO_3$. Other common errors included $C_2O_3H_6$, $C_3O_3H_5$ and $3COH_2$. Many candidates disadvantaged themselves by writing the numbers as large numbers or as superscripts. Many need more practice in writing chemical formulae.

(d) Many candidates completed the sentences correctly. The most common errors were large instead of small, polymers instead of monomers and atomic instead of molecular.

Question 3

Parts **(a)(iii)** balancing an equation and **(b)(i)** word equation were answered well by many candidates. Some candidates gave well-reasoned and step-by-step answers to **(a)(i)** separating copper from selenium. Others wrote vague and contradictory arguments and did not use the information in the table properly. Many candidates need more practice in how to answer this type of free response question. The structure of ethanol in **(a)(ii)** was not well known. Some candidates identified the pollutant gas and its source in **(b)(iii)**. Others gave vague answers. In **(c)** some candidates identified the reaction as endothermic but either did not explain why or referred to bond breaking or energy without further qualification.

(a) (i) The best answers mentioned adding an organic solvent then filtering to obtain the copper as a residue or filtering to obtain the selenium as a solution in organic solvent. Many candidates misinterpreted the question and suggested adding organic solvent or water to separate portions of the copper and selenium rather than to the mixture. Others suggested adding water to the mixture, despite the fact that the information in the table showed that both copper and selenium are insoluble in water. Many candidates did not gain the mark for filtration because they did not mention what was found on the filter paper. A significant minority suggested that the selenium was the residue. Many candidates referred to crystallising selenium and suggested evaporating to crystallisation point rather than evaporating off all the solvent. Better answers referred to washing and drying with the appropriate qualifications, e.g. 'wash with water', 'dry in a drying oven'. Others just repeated the 'dry' in the stem of the question and did not gain credit. Candidates should read the information in the table and stem of the question carefully and not assume that every question with 'pure dry samples' in the stem of the question is about the preparation of salts.

(ii) A minority of the candidates drew the structure of ethanol showing all of the atoms and all of the bonds. Others drew the OH group without the bond. Common errors included drawing carboxylic acids or aldehydes instead of alcohol or drawing incorrect partial structures such as HC_2O–H. A significant number of candidates put a double bond between the carbon atoms or drew the functional group as C–H–O instead of C–O–H. Others drew alkanes rather than alcohols, methane being commonly seen. Candidates should practice drawing both molecular and displayed formulae for the limited number of organic compounds required for the core paper.

(iii) A majority of the candidates balanced the equation correctly. The most common error was to balance with four fluorine molecules.

(b) (i) Many candidates completed the word equation correctly. Most candidates correctly identified copper sulfate and water; some suggested hydrogen instead of water. Fewer candidates identified sulfur dioxide. The most common errors here being sulfur oxide, sulfuric oxide or sulfuric acid.

(ii) The best answers selected sulfur dioxide and gave a suitable source such as 'burning fossil fuels' or 'from volcanic eruptions'. Many gave vague answers when trying to identify the source of sulfur dioxide, e.g. making chemicals, industries, burning sulfur. Others did not qualify their answers sufficiently, e.g. 'combustion of fuels' (without the 'fossil').

(c) A minority of the candidates gave good answers, which included both the term *endothermic* and the idea of heat being absorbed. Others either suggested exothermic or referred to bond breaking and bond making. Some candidates wrote about energy being absorbed but did not refer to the essential word 'heat'. Candidates should be aware that all thermal decomposition reactions are endothermic.

Question 4

Parts **(a)(i)** (unsaturation), **(b)(i)** (reduction), **(b)(ii)** (balancing an equation) and **(c)(i)** (choosing apparatus) were answered well by many candidates. Many did not know the test for an unsaturated compound in **(a)(ii)** and many candidates did not respond to this part. Few candidates gave a clear, concise answer to **(c)(ii)** when trying to explain the function of the litmus in a titration.

(a) (i) Many candidates identified the C=C bond as being responsible for unsaturation. The most common error was to refer to the COOH. Others wrote vague statements about carbon atoms or carbon bonds without reference to the double bond, e.g. 'there are two carbon bonds'.

(ii) A minority of the candidates knew the correct colour change when aqueous bromine reacts with an unsaturated compound. Others either suggested universal indicator or litmus or an 'emulsification test'. A wide variety of answers not related to a specific qualitative test were seen, e.g. 'cracking'. A significant number of candidates did not respond to this question.

(b) (i) Many candidates quoted the definition for reduction given in the core section of the syllabus, as the removal of oxygen from a compound. Common errors included the suggestion that oxygen is removed from an element or that oxygen is reduced. Many gave a non-chemical answer, e.g. 'getting smaller' or 'formula reduced'. Although other definitions were accepted, many candidates gave incorrect answers such as 'reduction is loss of electrons' or 'oxidation number gets less'. Candidates should learn the definitions required for the core paper.

(ii) Many candidates were able to balance the chemical equation. The most common error was to suggest 2HI.

(iii) Some candidates knew the percentage of oxygen in the air. A common error was to suggest 78%; the value for nitrogen. Others gave values which were near 21%, but not quite accurate enough. Values between 22 and 29% were commonly seen.

(c) (i) A majority of the candidates suggested a suitable piece of apparatus; pipette or burette being the most common correct answer. The best answers suggested a volumetric pipette. A few candidates disadvantaged themselves by suggesting a dropping pipette. The most common incorrect answer was a measuring cylinder.

(ii) Few candidates gave a clear, concise answer when trying to explain the function of the litmus in a titration. The best answers focussed on the idea that the litmus changed colour when the end point was reached or the acid had just neutralised the alkali. Most candidates suggested either that 'it changes colour when the alkali is added to the acid' or that 'it shows when the reaction has occurred'. Such answers are not precise enough. The majority of candidates thought that litmus showed the pH of the solution. Candidates should realise that universal indicator is the only indicator that is used to determine the pH.

(iii) Some candidates knew the correct colour change from red to blue. Many thought that the acid was being added to the alkali and gave the reverse colour change. Other common errors included yellow to green and brown, or some other colour, to colourless.

Question 5

Some candidates responded well to this question, especially in **(b)(i)**, **(b)(ii)** and **(c)(i)**. Few gave observations in **(b)(iii)**. Many did not realise that both magnesium and graphite conduct electricity and so suggested in **(b)(iv)** that graphite was a better conductor than magnesium. In **(c)(ii)** the relative reactivity of halogens and **(c)(iii)** the test for bromide ions, were answered successfully by a minority of candidates.

(a) Some candidates gave clear descriptions of the arrangement and motion of the particles in a liquid and in a gas. The best answers made it clear that the arrangement was irregular in both and that the motion in liquids was restricted or that the particles slide over each other and that the motion in the gas was rapid and random. Many responses did not make it clear whether it was separation or motion that was being discussed. Other candidates wrote about the bulk properties of liquids and gases. A considerable number of candidates contradicted themselves, e.g. 'particles are close to each other and slightly far apart'. Candidates should be encouraged to set out each part of their answer clearly, e.g. arrangement – random, motion – sliding over each other.

(b) (i) Many candidates labelled either the anode or the electrolyte correctly. Fewer obtained both marks. Many did not gain the mark for the anode because there was no line connecting the word anode to the anode in the diagram. Many candidates seemed uncertain which was the anode and put the label near the top of the anode near the positive sign and the circuit but with no connecting line. A considerable number of candidates who did add a connecting line, drew it to the wires in the circuit or just to the + sign. Other candidates drew a connecting line from the word electrolyte to the circuit, power pack or the basin. A significant number of candidates did not respond to this question.

(ii) Some candidates predicted the products at the electrodes correctly. Others gave the correct products at the incorrect electrodes. A considerable number of candidates disadvantaged themselves by suggesting that the products were ions. Others did not seem to understand the meaning of the word 'product' and gave answers such as 'anode and cathode' or 'movement of positive ions and movement of negative ions'. A few candidates suggested products such as sodium and chlorine, which bore no relationship to the ions in the electrolyte.

(iii) Very few candidates gave a suitable observation at the positive electrode. The best answers referred to a brown colouration or a brown gas near this electrode. Many suggested 'bromine is formed' or 'a gas is formed', which are not observations. Other incorrect answers included 'electrode increases in size' or 'precipitate formed'. Candidates should understand the difference between observations and conclusions.

(iv) Many candidates did not realise that both magnesium and graphite conduct electricity and so suggested that graphite was a better conductor than magnesium or that graphite conducted but magnesium did not. The best answers suggested that graphite is inert whilst magnesium can react with the electrolyte. Others gave rather vague answers, suggesting that graphite is less reactive than magnesium. A considerable number of candidates just referred to the structure of graphite or the fact that graphite does not dissolve, without mentioning lack of reactivity.

(c) (i) Most candidates completed the word equation correctly. The most common errors were potassium chlorine instead of potassium chloride and bromide, oxygen or hydrogen instead of bromine.

(ii) A minority of the candidates compared the reactivity of iodine and bromine. The most common errors involved a comparison of bromine with potassium bromide or potassium. Many candidates simply referred to the relative positions of bromine and iodine in Group VII without mentioning relative reactivity. Others tried to answer the question by referring to electronic structures, often mentioning full shells of electrons.

(iii) The best answers included both the words cream and precipitate. The most common error was to suggest that a white precipitate was formed. Some candidates were not sure about the colour and suggested 'white or cream'. A wide variety of other colour precipitates were seen, especially black, brown or green. Other candidates did not focus on the word 'observe' and gave the name of the substance formed or the type of reaction. A significant number of candidates did not respond to this question.

Question 6

This was one of the best answered questions on the paper. Most candidates gave good answers to **(a)** questions about four structures and **(b)** fertilisers. Many candidates did not appreciate in **(c)** that ammonium salts react with sodium hydroxide to release ammonia or that ammonia is an alkaline gas.

(a) (i) Most candidates realised that titanium was an element. The most common error was to suggest the other giant structures **T** or **R**.

(ii) Most candidates identified **T** as an ionic structure.

(iii) Many candidates identified carbon dioxide as a gas. The most common error was to suggest the other covalent structure, **R**.

(iv) Most candidates realised that **R** was a polymer. The most common error was to suggest **S** carbon dioxide.

(b) A majority of the candidates recognised the importance of potassium, nitrates and phosphates in fertilisers. The most common error was to suggest hydrogen sulfide.

(c) Many candidates did not appreciate that ammonium salts react with sodium hydroxide to release ammonia or that ammonia is an alkaline gas. The majority of candidates just repeated the stem of the question and wrote about the methyl orange changing colour. A significant number thought that the gas released was acidic or that an acid was formed whose fumes changed the colour of the indicator paper. Others referred to the pH changing without further qualification.

Question 7

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

(a) (i) The majority of candidates read the graph correctly. The most common error was to misread the scale and suggest 11.6 cm^3 or 12.5 cm^3.

(ii) Most candidates drew a curve. A few drew a straight line or two intersecting straight lines. Few candidates drew the curve below the one drawn for the zinc powder. The main error was to join the curves either at the beginning or at the end. A significant number of candidates did not respond to this question.

(b) (i) Most candidates realised that the rate would decrease. A significant number of candidates muddled rate with time and either gave answers related to shorter time or increased rate. Better performing candidates realised that rate is inversely proportional to time.

(ii) Nearly all the candidates gave an answer related to catalysis or increased rate of reaction. A few confused rate and time. Others did not gain the mark because they mentioned a change in rate rather than an increase in rate.

(c) Most candidates gave at least one correct physical property shown by most metals and many could give two. Others were not always able to distinguish the properties of transition elements from those of typical metals and as a result included high density, high melting and boiling point and strength in the answer. A few assumed that the question was about Group I metals and gave properties such as soft and low density. The most common properties that were given credit were conducts heat and / or electricity, ductile and malleable. A few candidates mentioned that metals were solid but omitted the essential extra words ‘at room temperature’.

(d) (i) A significant number of candidates thought that an alloy was a compound rather than a mixture. Most candidates mentioned metals with other metals in their answer. Fewer included the essential word ‘mixture’. Others wrote about mixtures of metals combined, not appreciating the chemical meaning of combined. Candidates should be encouraged to make a list of the chemical definitions that appear in the syllabus, together with their meanings and underline the important parts of the definition.

(ii) Many candidates gave a suitable use for stainless steel; cutlery and surgical tools being the answers most often seen. Some answers were too vague, e.g. ‘in the kitchen’, ‘for kitchenware’, which could be pottery or plastic or ‘in buildings’. Candidates should be advised that they should learn the examples in the syllabus and not choose an example which may or may not contain a small amount of stainless steel.

Question 8

Many candidates gave good answers to **(a)(i)**, **(a)(ii)** and **(b)(iii)**. Fewer candidates were able to explain why it is difficult to predict the density of caesium from the information in the table in **(a)(iii)**, or give the flame colour of potassium in **(b)(i)** or to suggest why potassium floats on water in **(b)(ii)**.

(a) (i) Many candidates gave a good description of the trend in the hardness. The most common error was the lack of precision in answering this question, e.g. just decreases alone is insufficient as the direction of the trend ‘down the group’ was needed.

(ii) Nearly all the candidates predicted the melting point of rubidium correctly. Some candidates gave values well above 60°C.

(iii) The best answers focussed on the fact that there was no consistent trend in the densities from sodium to rubidium. A majority of the candidates did not use the information in the table and wrote about different volumes, hardness or melting points. Others wrote vague statements about the density being difficult to predict. A number assumed that the density was related to the radioactive nature of caesium or that caesium was very reactive.

(b) (i) Some candidates knew the flame colour of potassium. Others appeared to guess and a wide variety of different incorrect colours was seen. The most common errors were to suggest red or blue.

(ii) Some candidates explained why potassium floats on water. The best answers involved a comparison of the density of potassium with the density of water. Those who realised that density was involved often gave answers that were not precise enough, e.g. ‘potassium has a low density’.

(iii) Many candidates completed the dot-and-cross diagram correctly. Most candidates drew a single pair of electrons in the overlap area. Others added extra non-bonding electrons to both hydrogen atoms, usually one electron per atom. A few candidates completed each circle with six non-bonding electrons.

CHEMISTRY

Paper 0620/33
Theory (Core)

Key messages

Many candidates need more practice in interpreting the stem of a question.

Many candidates need to write with greater precision and to include key terms, which will lead to a good answer.

Many candidates need more practice in questions involving qualitative analysis, electrolysis and the physical properties of molecules, metals and ionic structures.

Some candidates need further practice in answering free response questions.

General comments

Many candidates tackled this paper well, showing a good knowledge of core chemistry. Nearly all candidates were entered at the appropriate level. The standard of English was generally good. Most candidates attempted all parts of each question. The exceptions were **Questions 2(b)**, **4(a)(iii)**, **5(c)** and **5(d)(i)**, where a significant number of candidates did not respond.

A significant proportion of the candidates did not appear to read the stem of the question carefully enough. For example, in **Question 1(a)(i)** some candidates assumed that the question referred to the number of outer shell electrons rather than the 'total of eight electrons' stated in the stem of the question. In **Question 2(a)(i)** many candidates did not appear to take note of the phrase 'two major differences' and gave answers referring to minor differences. In **Question 5(c)** many candidates gave the test for chlorine gas rather than chloride ions.

In several questions many candidates did not respond to the key term 'observations' and gave explanations instead. For example, in **Question 5(d)(iii)** many candidates suggested that 'chlorine is formed' or 'a gas is formed', which are not observations. Others wrote statements such as 'negative ions go to the positive electrode'.

In **Question 6(a)(iv)** some candidates confused the terms macromolecule and molecule. Candidates should ensure that they know the meaning of the key terms used in the syllabus. In **Question 8(b)(ii)** many candidates did not appear to read the words 'in industry' and gave domestic uses of water. Better performing candidates often underline or circle the key parts of the stem of the question and return to these to check that the question has been correctly answered. Candidates need to ensure that they label their diagrams when instructed to do so. Many did not label their diagrams or labelled them inaccurately in both **Question 2(d)** chromatography and **Question 7(a)** apparatus for gas collection.

Many candidates need to write with greater precision and to include key terms, which will lead to a good answer. For example, in **Question (2)(a)(i)** some candidates just repeated the data from the table. In **Question 2(d)** many candidates wrote statements about how the solvent separated the dyes in chromatography that were too vague or incomplete to be credited, e.g. 'the spots separate up the paper', rather than 'the solvent moves up the paper and allows the spots to separate'. In **Question 3(a)(ii)** some candidates wrote about not rusting when they meant not corroding. In **Question 4(a)(ii)** some candidates suggested that bromine water was discoloured or went clear rather than decolourised. In **Question 4(b)** some candidates disadvantaged themselves by writing about 'changes in pH' rather than the more precise 'decrease in pH'. Better performing candidates carefully revised the definitions of scientific terms, which appear in the syllabus, e.g. electrolyte and cathode, so that they are able to label diagrams correctly.

Some candidates need to take more care over drawing diagrams of apparatus. For example, in **Question 2(d)** chromatography, many candidates drew the spot of dye in line with or slightly below the level of the solvent.

Many candidates need more practice with qualitative tests. For example, very few candidates knew the test for sodium in **Question 2(b)**, the test for an unsaturated hydrocarbon in **Question 4(a)(ii)** or the test for chloride ions in **Question 5(c)**. Candidates should ensure that they do not confuse the tests for molecules and ions, e.g. chlorine and chloride.

Some candidates need more practice in answering questions about electrolysis, specifically distinguishing the anode from the cathode, naming the electrolyte and predicting the products of electrolysis at the anode and cathode. When predicting products of electrolysis, candidates should first consider whether the electrolyte is a molten compound or aqueous solution. If it is the former, they should remember that a metal is produced at the cathode and a non-metal at the anode and not the metal ions.

Many candidates need further revision in understanding the differences in physical properties of metals, simple molecules, giant covalent molecules and ionic structures in **Question 6(a)**. Candidates should be encouraged to compare these by means of a table showing diagrams of the typical structures, e.g. diamond, sodium chloride, nitrogen and zinc together with their typical properties of electrical conductivity, solubility and melting point.

Some candidates need more practice in answering questions involving extended answers such as **Question 5(a)(ii)**, the arrangement and motion of particles in a liquid and a gas. Candidates should set out each part of their answer clearly, e.g. arrangement in gas is random, motion in gas is moving everywhere rapidly, arrangement in solid is regular, motion in solid is only vibrating.

Questions involving general chemistry, were tackled well by some candidates. Many candidates were able to balance simple chemical equations and extract relevant information from tables of data. Others need more practice in naming compounds and writing formulae, especially formulae of organic functional groups such as carboxylic acids.

<u>Comments on specific questions</u>

Question 1

This was one of the best answered questions on the paper, the exception being in **(a)(iv)** where fewer candidates identified the electronic structure of a metallic element. Many candidates deduced the numbers of at least two of the sub-atomic particles in part **(b)**.

(a) (i) The majority identified the atom with eight electrons. The most common error was to suggest **B**, which has eight electrons in its outer shell.

(ii) Many candidates correctly identified an atom in Group V. The most common incorrect answer was **D**, which has six electrons in the outer shell.

(iii) Nearly all the candidates correctly identified **B** as having a complete outer shell of electrons. The most common incorrect answer was **D**.

(iv) Some candidates correctly identified **A** as having the electronic structure of a metallic element. The most common incorrect answers were to suggest **D** or **B**, both elements having three electron shells.

(v) Many candidates correctly identified electronic structure **A** as an atom that forms an iron with a single positive charge. The most common incorrect answers were to suggest **B**, which has a full outer shell or **D,** which requires two electrons to complete its octet.

(b) Some candidates were able to deduce the numbers of at least two of the sub-atomic particles. Nearly all the candidates deduced the correct number of neutrons. A considerable number of candidates suggested 22 protons for neon and 65 protons for the copper ion by selecting the mass number rather than the atomic number. Few candidates deduced the number of electrons in the Cu^+ ion. Most ignored the fact that Cu^+ is an ion and gave an answer of 29. Very few gave the answer 30 by adding electrons rather than removing them.

Question 2

Many candidates were able to extract relevant information from the table in **(a)(i)** and were able to do the calculations in **(a)(ii)** correctly. Fewer knew the test for sodium ions in **(b)**. Some candidates deduced the molecular formula of taurine correctly in **(c)**. Others omitted either the nitrogen or the sulfur. In **(d)** many candidates described how a suitable chromatography apparatus could be used to separate a mixture of dyes. Others made basic errors, either in drawing their diagrams or explaining the procedure in writing.

(a) (i) The best answers stated that potassium ions had a greater concentration in squid nerve cells than in human blood plasma and sodium ions had a greater concentration in human blood plasma than in squid nerve cells. Some candidates misread the table and suggested that squid nerve cells had higher concentrations of both sodium and potassium. Others did not respond to the phrase 'major differences' in the stem of the question and chose to compare magnesium or chloride ion concentrations. A considerable number of candidates just repeated the data in the table. This was particularly noticeable when candidates chose to compare hydrogencarbonate ion concentrations. The most common answer here being 'there is a trace in the nerve cells and 1.5 in the blood'. Candidates should realise that marks will not be given for just repeating the data in the table or the words in the stem of the question as something extra is always needed.

(ii) Many candidates calculated the mass of potassium ion correctly. The most common errors were 0.26, obtained by dividing 4 by 15.6 or 0.0624, obtained by dividing 15.6 by 250.

(b) The few candidates who realised that Group I metals produce characteristic flame colours often obtained both marks for the yellow colour of the sodium flame. The most common errors were to suggest a red or lilac flame. Many candidates thought they were dealing with sodium chloride and suggested adding silver nitrate and noting the colour of the precipitate. Others suggested adding sodium to water but made no mention of a flame. Another common error was to suggest adding sodium hydroxide. A significant number of candidates did not respond to this question. Candidates should realise that the tests for Group I ions and copper ions involve the use of a flame test and not a precipitation reaction.

(c) Some candidates wrote the correct formula. Others counted the number of atoms but did not write a proper chemical formula, e.g. C2 + H7 + O3 + N + S. Other candidates wrote a formula that was part structural, e.g. $C_2NSO_2H_6OH$. Other common errors included miscounting the hydrogen or oxygen atoms or omitting the nitrogen atom or the sulfur atom or both. A few candidates disadvantaged themselves by writing the numbers superscripted or too large.

(d) The best answers showed a fully labelled drawing of the chromatography apparatus with the chromatography paper dipping into a named solvent in a deep beaker. These answers also showed a labelled spot of ink on the base line and the spot of ink above the solvent level. Many candidates did not label their diagram. Many candidates drew the spot of dye on the base line below the level of the solvent. Others wrote vague statements about the solution, so that it was not clear, in the absence of the word solvent, whether the solution referred to the solvent or the dye solution. Many candidates did not use a beaker for the chromatography and dipped the paper into a solvent in a watch-glass evaporating basin or did not draw a vessel at all. A deep beaker with a lid is necessary for chromatography to stop the paper drying out. Very few candidates mentioned that the solvent moves up the paper and so separates the dyes. Most candidates just wrote statements such as 'the dyes are separated by the solvent'. Candidates should ensure they always label their diagrams, draw apparatus with care and write their answers with greater precision.

Question 3

Parts **(b)(i)**, the word equation and **(d)(i)**, the equilibrium sign, were answered well by many candidates. In **(a)(ii)**, explaining why brass is used for ship propellers, many candidates wrote answers that were too vague to award credit. In **(b)(ii)** few candidates gave a suitable source of nitrogen oxides. Many candidates did not refer to the equation when explaining the reduction of zinc oxide in **(c)** or use the information in the equation in **(d)(ii)** to explain the change in colour of iron(II) sulfate.

(a) (i) Some candidates recognised diagram **L** as being an alloy, having two different sized atoms randomly arranged. The most common errors were **J**, where the atoms were ordered and **M**, which showed diatomic molecules. Candidates should realise that alloys are metals and so the atoms are close together rather than separated.

(ii) A minority of the candidates gave good answers such as 'alloys are stronger than the pure metals alone'. Others did not give a comparison and just wrote 'strong' or 'hard', which was not sufficient because the pure metals are also strong and hard. Candidates should be advised that if they see the words 'rather than' or 'instead 'of' in the stem of the question, they should give a comparative answer. This could be in the form of 'brass is strong but copper is not as strong' but not 'brass is strong but copper is weak', which was seen a few times. Other common errors were to suggest that brass had a lower density or was more malleable. A significant number of candidates suggested that brass did not rust. This was not sufficient to gain credit because neither copper nor zinc rust.

(b) (i) Many candidates completed the word equation correctly. Most candidates correctly identified zinc nitrate and water; some suggested hydrogen instead of water. Fewer candidates identified nitrogen dioxide. Common errors included nitric acid, nitrate or nitrate dioxide.

(ii) Some candidates identified the pollutant gas from **(b)(i)**. Few candidates gave a suitable source. The best answers involved 'lightning' or 'combination of nitrogen and oxygen in car engines'. Many candidates did not realise that high temperatures and / or pressures are required to get nitrogen to combine with oxygen and suggested 'burning fossil fuels'. Many imprecise answers were seen, e.g. 'from industries'. Some candidates just repeated what was shown in the equation as 'the reaction between zinc and nitric acid'. A significant number of candidates suggested 'acid rain'.

(c) Many candidates did not respond to this question with the precision required and gave answers that did not refer to the equation. The best answers referred to the loss of oxygen from the zinc oxide, rather than just loss of oxygen, which does not refer to the equation. Common errors included the suggestion that oxygen is removed from an element or that oxygen is reduced. Many gave a non-chemical answer, e.g. 'getting smaller' or 'formula reduced'. Many candidates gave incorrect answers such as 'copper oxide loses electrons' or 'oxidation number of copper oxide gets less'. Candidates should revise the definitions required for the core paper.

(d) (i) Most candidates gave the correct symbol for a reversible reaction. The most common errors were single headed arrows → or =>.

(ii) Some candidates knew that water had to be added to white iron sulfate to change it to green iron sulfate. Others suggested adding more iron sulfate, adding sodium hydroxide or 'separate the water from the iron sulfate'.

Question 4

Parts **(a)(i)** and **(b)** were answered well by many candidates. Many did not know the result of the test for an unsaturated compound in **(a)(ii)** and very few were able to draw the structure of the COOH functional group in **(a)(iii)**. In **(a)(iv)** some candidates recognised that acids turn blue litmus red. Many candidates did not appear to realise that compound **P** was acidic because if its COOH group.

(a) (i) Many candidates identified the C=C bond as being responsible for unsaturation. The most common error was to refer to the COOH. Others wrote vague statements about carbon atoms or carbon bonds without reference to the double bond, e.g. 'there are two carbon bonds'. Other common incorrect answers included 'contains oxygen and hydrogen' and contains 'carbon and hydrogen'.

(ii) Some candidates knew the colour change when excess compound **P** was added to aqueous bromine. The best answers suggested orange to colourless. Other candidates gave answers which were too imprecise to be awarded credit, e.g. the aqueous bromine goes clear or became discoloured. Other common errors included blue to red, confusing this test with litmus test or green for the initial colour of the bromine. When revising tests for ions and elements, candidates should not forget to include the test for unsaturation to the list given at the end of the syllabus or make their own list to include all the chemical tests given in the syllabus.

(iii) A minority of the candidates drew the structure of the carboxylic acid functional group showing all of the atoms and all of the bonds. Common errors included drawing alcohols or aldehydes instead of carboxylic acids or drawing structures with double bonds between carbon and hydrogen atoms. Many candidates repeated the –COOH group in the stem of the question as C–O–O–H. A significant number of candidates drew the functional group with a C–H–O or C=O–H. Others drew structures with only single bonds. Candidates should practice drawing both molecular and displayed formulae for the organic compounds required for the core paper. A significant number of candidates did not respond to this question.

(iv) Some candidates realised that compound **P** was an acid and suggested that the litmus solution turned red; others suggested that the litmus turned blue. A minority of candidates suggested other colours such as green.

(b) (i) Some candidates realised that the pH decreased as more acid was added. The best answers focussed on the rate of the change, i.e. slowly decreasing at first then rapidly decreasing when 14 cm^3 of acid had been added. Many candidates did not answer precisely enough and just referred to 'change in pH' instead of 'pH decreases'. Better performing candidates remembered to state the direction of the change.

(ii) Many candidates deduced the correct pH. Others misread the graph and suggested pH 12.6 or pH 13. Others gave an answer that was too vague, such as 'alkaline'.

(iii) A majority of the candidates deduced the volume correctly. The most common errors arose from a misreading of the graph; 15 cm^3 being the most common incorrect answer.

Question 5

Some candidates gave well-argued responses to the extended answer question in **(a)**. Many candidates were able to balance the equation in **(b)** correctly. Fewer knew the test for chloride ions in **(c)**. Some candidates gave good answers to the electrolysis question in **(d)**. Others need more practice in questions involving identifying the cathode and electrolyte and in naming the products of electrolysis.

(a) Some candidates gave clear descriptions of the arrangement and motion of the particles in a gas and in a solid. Others wrote unnecessarily about intermolecular forces, which is not required in the core paper. The best answers made it clear that the arrangement was regular in a solid and irregular or random in the vapour and that the motion in a solid was only vibrating or not moving from place to place and that the motion in the gas was rapid and random. Some candidates wrote their answers without making it clear whether it was arrangement or motion that was being discussed. Others wrote about the bulk properties of solids and gases. A considerable number of candidates contradicted themselves, e.g. 'particles are close to each other and slightly far apart'. Candidates should be encouraged to set out each part of their answer clearly, e.g. arrangement – regular, motion – moving fast and randomly.

(b) Most candidates balanced the equation correctly. The most common error was to suggest 4(H_2SO_4) or 4(H_2O). Other common errors were 3(H_2O) or 6(H_2O).

(c) The best answers gave the test reagent as silver nitrate acidified with nitric acid and included both the words white and precipitate for the result. Most candidates chose an incorrect test reagent; sodium hydroxide, litmus or flame test being the most common incorrect suggestions. Many candidates misread the question and gave the test for chlorine rather than chloride ions. Some of those who did give the correct test reagent, disadvantaged themselves by adding hydrochloric acid, not realising that this acid contains chloride ions. Others suggested adding sulfuric acid. Candidates should be advised that in tests for halides it is always nitric acid that is added. The most common error in the result was to suggest that a yellow precipitate was formed. A minority of candidates suggested incorrect colours such as red or green. A significant number of candidates did not respond to this question.

(d) (i) Some candidates labelled either the cathode or the electrolyte correctly; fewer obtained both marks. The positive electrode was often labelled as the cathode. A few candidates did not gain the mark for the cathode because there was no line connecting the word cathode to the cathode in the diagram. Some candidates who did add a connecting line, drew it to the wires in the circuit or just to the + sign. Other candidates drew a connecting line from the word electrolyte to the circuit, power pack or the basin. A significant number of candidates did not respond to this question.

(ii) Some candidates predicted the products at the electrodes correctly. Others gave the correct products at the incorrect electrodes. A considerable number of candidates disadvantaged themselves by suggesting that the products were ions, copper(II) being a common error for the product at the negative electrode. Others did not seem to understand the meaning of the word 'product' and gave answers such as 'anode and cathode' or 'movement of positive ions and movement of negative ions'.

(iii) Very few candidates gave a suitable observation at the positive electrode. The best answers referred to bubbles of a green gas at this electrode. Many did not give an observation and suggested that 'chlorine is formed' or 'a gas is formed', which are not observations. Other incorrect answers included 'electrode becomes thicker' or 'negative ions go to the positive electrode'. Candidates should understand the difference between observations and explanations or conclusions.

Question 6

This was the least well answered question on the paper. Many candidates gave good answers to **(a)(i)** identifying a compound and **(c)** phosphates in fertilisers. Other candidates need to revise the differences between the physical properties of ionic, simple molecular and metallic structures, as in **(a)(ii – v)**. In **(b)** a minority of the candidates realised that iodine was formed; fewer gave a correct reason. In **(d)** few candidates realised that ammonia was formed by the reaction between calcium hydroxide and ammonium salts.

(a) (i) Most candidates identified **S,** potassium iodide, as a compound. The most common error was to suggest **R**, diamond.

(ii) Some candidates realised that metals conduct electricity when solid. The most common errors were to suggest the ionic structure, **S**, which only conducts when molten or in aqueous solution or diamond, **R**, which candidates perhaps confused with graphite.

(iii) Some candidates identified nitrogen as having a low melting point. The most common error was to suggest the metallic structure, **U**. Many candidates would benefit from further revision about the differences between the physical properties of ionic, simple molecular and metallic structures.

(iv) Many candidates recognised **R**, diamond, as being a macromolecule. The most common incorrect answer was **T**, nitrogen, possibly due to candidates not reading or taking note of the prefix 'macro' and selecting a simple molecule instead. Other candidates selected **S**, ionic structure, which is a giant structure but not covalent.

(v) Some candidates realised that transition elements such as manganese are catalysts. The most common incorrect answers were **T**, nitrogen, and **S**, ionic structure.

(b) Some candidates realised that the brown coloration was due to iodine. Others suggested potassium iodide and a considerable number suggested bromine, even though there was no bromine or bromide in the reactants. A minority of the candidates compared the reactivity of iodine and chlorine. The most common errors involved a comparison of chlorine with potassium chloride or potassium. Many candidates simply referred to the relative positions of chlorine and iodine in Group VII without mentioning relative reactivity. Others tried to answer the question by referring to electronic structures, often mentioning full shells of electrons

(c) Many candidates identified calcium phosphate as a component of fertilisers. The most common errors were to suggest copper sulfide or tin(IV) oxide.

(d) A minority of the candidates realised that ammonia was produced by the reaction between calcium hydroxide and ammonium salts. The best answers, which were rarely seen, suggested that ammonia would escape from the soil because it is a gas and so the extra nitrogen available to the plant from the fertiliser is no longer available. Many candidates thought that ammonium chloride was alkaline and so the addition of extra alkali made the soil pH too high for plants to grow. Others thought that calcium hydroxide was acidic and the soil would be neutralised. Some candidates realised that there was a chemical reaction between calcium hydroxide and the ammonium salts, but most just referred to them mixing. The reaction of ammonium salts with alkalis was not well known; this is an area of the syllabus that candidates need to revise more.

Question 7

Many candidates performed reasonably well in this question, especially in **(b)** taking readings from the graph, **(c)(i)** sketch graph and **(d)(ii)** reactions in the blast furnace. In **(a)** some candidates drew clear labelled diagrams, whilst others either drew apparatus that would not work or did not label their diagrams.

(a) The best answers showed a labelled gas syringe connected to a flask with no gaps in the apparatus. The gas syringe was not always well drawn. The mark was awarded if it was clear that there was a plunger present. The best answers also showed graduation marks. Those candidates who drew a measuring cylinder, rarely showed it inverted in a vessel of water. Many showed measuring cylinders without graduation marks, so that if there was no label, it was difficult to ascertain whether the glassware drawn was a measuring cylinder or gas jar. Many candidates did not draw workable apparatus because they drew apparatus that had a constant volume, e.g. test tube, connected to the flask. Others drew a connecting tube, which dipped into the reaction mixture, so preventing or reducing the amount of gas exiting the flask. Candidates should be encouraged to practise drawing apparatus, including drawing graduation marks on syringes or measuring cylinders as well as ensuring that their diagrams are fully labelled. Others should be encouraged to realise that if a gas is being collected, there must be something that moves in the apparatus to allow for the increase in volume of the gas.

(b) (i) Most candidates read the graph with the required degree of accuracy. The most common error was to suggest 7 minutes; the finish point of the graph rather than the time when the reaction had just stopped.

(ii) Most candidates read the graph correctly. The most common error was to misread the graph to suggest a value of $95\,cm^3$ or $90\,cm^3$. A few candidates suggested $100\,cm^3$.

(c) Many candidates drew an initial gradient, which was less steep. A minority realised that the iron was in excess in both the concentrations of acid and so the acid would be used up first and the final volume of gas would be lower for the acid with a lower concentration. Others drew the line to reach the one already shown on the graph. In this type of graphical question, candidates should make sure that they check whether the acid or the other reactant is in excess.

(d) (i) Some candidates knew that hematite was an ore of iron. Others suggested bauxite or repeated the stem of the question and wrote ‘iron ore’. A wide variety of other incorrect answers were seen, including many related to the extraction of iron, e.g. coal, carbon, carbon monoxide.

(ii) Many candidates selected at least two correct responses from the list. The most common errors were ‘oxidises’ or ‘nitrogen’ instead of air, ‘dioxide’ or ‘tetrachloride’ instead of monoxide, ‘oxidises’ instead of decomposes and ‘tetrachloride’ instead of slag.

Question 8

This was one of the best answered questions on the paper. Many candidates gave good answers to **(a)** using information from the table, **(c)** balancing an equation and **(d)** electron arrangement. In **(b)(ii)**, use of water in industry many candidates either gave answers that were too imprecise to be credited or did not take note of the word ‘industry’ in the stem of the question.

(a)(i) Most candidates were able to extract relevant information about melting and boiling points of the halogens from the table. Most identified fluorine as a gas at room temperature and estimated the boiling point of chlorine within the range allowed. Those candidates who gave a range of values often did not gain credit because either the lower or higher value of the range was outside the acceptable range.

(ii) Some candidates realised that chlorine is a gas and so has a much lower density at room temperature than liquid bromine and solid iodine. Some candidates just repeated the stem of the question, stating that ‘fluorine and chlorine have a lower density than bromine and iodine’. Others did not appreciate the phrase ‘much lower’ in the stem of the question and wrote about the trend of densities rather than the distinction between chlorine and the elements lower in the group. A common error was to try to relate the difference to surface area or relative molecular mass.

(b) (i) Many candidates realised that chlorine kills bacteria. Others gave vague answers that were insufficient to gain credit e.g. ‘to clean the water’, ‘to purify it’ or ‘to remove impurities’.

(ii) A minority of the candidates gave precise enough answers to gain credit. Good answers included ‘to cool processes or machines which produce a lot of heat’ and ‘as a solvent’. Some candidates gave answers that were not precise enough, e.g. ‘for cleaning’. Many candidates ignored the key words ‘in industry’ in the stem of the question and gave answers such as ‘cooking’, drinking’ or ‘washing’.

(c) Most candidates balanced the equation correctly. The most common errors were to suggest 2(Cl_2), 1(Cl_2) or 6(Cl_2).

(d) Many candidates completed the electronic arrangement of chlorine correctly. The most common errors were to draw two bonding pairs of electrons or to draw five non-bonding electrons on each chlorine atom.

CHEMISTRY

Paper 0620/41
Theory (Extended)

Key messages

Candidates must ensure they read questions carefully to ensure that the answer they give addresses what has been asked. A common error is to 'describe' when a question asks for an 'explanation'.

When drawing organic structures, candidates should be aware of the valencies of the atoms they are representing; di- (or even tri-) valent hydrogen atoms and mono- or trivalent oxygen atoms were seen.

When a chemical equation is asked for, this means a balanced symbol equation using correct symbols/formulae and not a word equation.

General comments

The vast majority of candidates completed the entire paper in the allocated time. It was common for the very last part of the last question to not be attempted. Candidates must turn over every page of the question paper.

Candidates who read the questions carefully and had prepared for the examination thoroughly, produced some excellent answers that were well structured and detailed.

Candidates who gave working in the calculation in **Question 3(c)(i)** were often able to gain partial marks, despite their final answer being incorrect.

Comments on specific questions

Question 1

(a) The vast majority of candidates were able to identify aluminium as being used to make food containers. Silver was a common incorrect answer.

(b) Most candidates correctly identified calcium carbonate as being used to remove impurities.

(c) The main constituent of natural gas was well known. Sulfur dioxide was a common error.

(d) Almost all candidates knew that sulfur dioxide was a cause of acid rain.

(e) Most candidates knew that chlorine would bleach damp litmus paper. The most common incorrect answer was sulfur dioxide.

(f) Many correct answers were seen. However, this was the most poorly answered part of the opening question. The most common error was sulfur dioxide. While sulfur dioxide molecules are polar, their high solubility in water means that they do not contribute to climate change.

Question 2

(a) Almost all candidates gained some, if not all, of the marks available for completing the table. The two most common errors were to give the electronic structure of **D** as 2.8.7 or the charge of **D** as 0 or +1.

(b) This was very well answered. A small minority of candidates did not read the question carefully and tried to recall two isotopes they had met previously.

(c) Candidates who worked out that **Z** was in Group **I** of the Periodic Table normally correctly identified lithium as being less reactive. Weaker responses often seemed to include a random element.

(d) The majority of candidates could relate the lack of reactivity to the outer shell being full. Some candidates did not read the question carefully and so did not use the information in the table.

Question 3

(a) (i) Candidates who knew that the missing decomposition product was copper oxide were often able to gain both of the marks available. Many candidates thought the missing product was copper.

(ii) Those candidates who studied the diagram and read the question carefully were often able to realise that it must be the aqueous sodium hydroxide that prevented the nitrogen dioxide being collected. These candidates were able to explain that nitrogen dioxide reacted with sodium hydroxide. The majority of candidates did not make use of the information given. Many answers were incorrectly based on density or the fact that copper nitrate reacted with sodium hydroxide to make oxygen.

(b) While some fully correct answers were seen there were also many answers which showed a lack of understanding of how nitrogen dioxide is formed. The two most common errors were to state that the nitrogen (or oxygen) came from the fuel or that nitrogen dioxide was formed by a reaction of nitrogen monoxide (or nitrogen) with carbon dioxide in the catalytic converter.

(c) (i) Some well set-out and fully correct calculations were seen. Candidates who got the relative formula mass of copper(II) nitrate wrong were still able to gain a mark for the correct use of the incorrect M_r if it was clear what they had done. Some candidates did not show their working and so if they gave an incorrect answer, had to be awarded zero marks.

(ii) This question required use of the stoichiometric coefficients in the equation provided in **(a)** and the answer to the previous question part; only a few candidates realised this and so were able to give a correct answer.

(iii) Many correct answers were seen. A common error was to give an answer in dm^3 rather than cm^3, as specified in the question and on the answer line.

(d) (i) Better performing candidates correctly gave the formula of copper(II) hydroxide. A number of candidates did not read the question carefully and either named the product or tried to write an equation for the reaction.

(ii) Some excellent explanations were seen relating specific observations to the products formed in this displacement reaction. Many candidates described the observations, which they had already been given, rather than explaining them or invented additional incorrect observations.

(iii) Some fully correct answers were seen. It was clear that many candidates either did not know that ammonia is made when testing for nitrate ions or did not know the reagents required. It is important that candidates learn the anion, cation and gas tests for all papers and not just the practical or alternative to practical papers.

(e) (i) Most candidates showed that both carbon dioxide and water were produced. Only the better performing candidates produced a fully correct balanced equation. It was common for the other products to be incorrect or for one or more of the formulae to be incorrect. It is important that candidates are able to write correct formulae for the compounds met in this syllabus.

(ii) This was answered correctly by the majority of candidates.

(iii) This was answered correctly by the majority of candidates. The most common error was to state the process was 'respiration'.

Question 4

(a) (i) Most candidates stated that sulfur is obtained from fossil fuels or volcanic sources. Many candidates did not read the question carefully and gave a source of sulfur dioxide rather than sulfur.

(ii) This was known by the majority of candidates although the Haber process was a common error.

(iii) The best answers gave a balanced equation using the reversible reaction arrows and correctly identified all conditions used. Overall, correct equations were rarely seen with the most common error being that they were not balanced or that oxygen was monoatomic. Conditions quoted, while often correct, were sometimes mixed up with conditions for the Haber process.

(b) (i) Despite the stem to **(b)** stating that the sulfuric acid acts as a dehydrating agent, many candidates did not identify hydrogen as the substance removed.

(ii) Better performing candidates were able to identify carbon as the black solid. The majority of answers were incorrect, with non-existent compounds of carbon, such as carbon sulfate, being a common error.

(c) (i) The majority of candidates could state that oxidation is the loss of electrons. Some candidates did not read the question carefully and gave an answer in terms of oxygen or just stated that oxidation is electron transfer.

(ii) The dot-and-cross diagram was completed correctly by the majority of candidates. The most common error was to either omit the non-bonding electrons on sulfur or to add additional non-bonding electrons on hydrogen.

(iii) Better performing candidates gave fully correct and clearly explained answers in terms of weak intermolecular forces. The majority of candidates often suggested the weak forces were between atoms or that covalent bonds were weak. There was clearly some confusion over the terms *intermolecular* and *intramolecular* – although similar, these two terms have very different meanings. Candidates should refer to the forces between molecules as intermolecular and forces within a molecule as covalent bonds and avoid the use of intramolecular altogether.

(d) (i) A common error was to not divide the volume used by 1000 and so have an answer three orders of magnitude too large. A minority of candidates incorrectly tried to make use of the relative formula mass of sulfuric acid.

(ii) This required the use of the 1:2 ratio in the equation. Many correct answers were seen. It was relatively common for candidates to halve rather than double their answer to **(i)**.

(iii) Better performing candidates completed this calculation correctly. A common error was for candidates to try and use the molar volume of a gas in working out the volume of the solution.

Question 5

(a) Many candidates knew that equilibrium involved a reversible reaction. Answers that stated that the forward and reverse reaction occurred at the same rate were uncommon. A common error was to say the forward and reverse reactions were the same - missing out the idea of rate, or that the concentrations of reactants and products were the same – the same does not mean constant.

(b) (i) This question required an explanation. Some candidates gave clear explanations; it was common for answers to just describe how pressure changed the yield, which was already stated in the question.

(ii) This question required a conclusion with an explanation. It was common for candidates not to give a conclusion but to describe the effects of pressure and temperature shown by the graph. Better performing candidates realised that the forward reaction must be exothermic because the yield decreased as temperature rose.

(c) (i) This was well answered, with almost all candidates identifying the start or the beginning as the point where the reaction was fastest. Some candidates were reluctant to commit themselves by stating the reaction was fasted in the first few minutes but not saying exactly when.

(ii) Most candidates realised the reaction would be faster and so drew a steeper line. Many of these did not realise that the catalyst would not change the final concentration of the hydrogen iodide.

(d) (i) Some fully correct answers were seen. Most candidates did not read the question carefully and so gave an answer based on yield rather than rate. Of those candidates that did base their answers on rate, many repeated information in the question and stated that the reaction would be faster because the concentration was greater. Candidates are expected to be able to explain the effect of increased concentration on rate in terms of an increased frequency of collisions.

(ii) Better performing candidates were able to give fully correct answers. Many candidates did not read the question carefully and tried to answer in terms of yield. Candidates are expected to be able to explain the effect of increased temperature on rate in terms of both the energy of the particles and the collision frequency.

Question 6

(a) (i) Common errors included missing out the 'only', describing the carbon and hydrogen as 'molecules' and describing the compound as an 'element'.

(ii) Some candidates had careless use of subscripts. For example, the general formula of alcohols is $C_nH_{2n+1}OH$; whereas $C_nH_{2n}+1OH$ is not acceptable, as this has only 2n hydrogen atoms and the plus sign now implies the OH is not part of the molecule.

(iii) Many candidates who had learned the characteristics of a homologous series performed well. A common error was to claim that members had the same physical properties.

(b) (i) Substitution reactions of alkanes require ultraviolet light (or sunlight). It was clear that many candidates were guessing at the answer and went for 'high temperature' or 'high pressure', as these are common incorrect reaction conditions.

(ii) Many candidates drew fully correct answers. Answers with more than one hydrogen substituted were common, as were structures where an H had been replaced by Cl_2 – which would mean that there was a divalent chlorine in the structure.

(iii) Correct answers were uncommon. The most common errors were to try and name the organic product or to name the product as hydrochloric acid. Since no water is involved in the reaction, the product is hydrogen chloride gas, this must dissolve in water to form hydrochloric acid. Candidates should be encouraged to read the questions carefully.

(c) Many candidates could correctly name the ester.

(d) (i) Many correct answers were seen. It was evident that a significant number of candidates did not know what a molecular formula was and so gave structures that showed some structure, such as C_4H_9OCOH, and so did not gain the mark.

(ii) This proved to be a challenging question for candidates, with few fully correct answers. Many were able to name the acid correctly; relatively few of those could correctly draw the structure. The omission of the hydrogen joined to the oxygen was a common error or putting the acidic hydrogen on the wrong oxygen (giving a trivalent oxygen atom). Some candidates were successful at drawing the structure of the alcohol; fewer could correctly name the alcohol. Butan-1-ol was a common error when the structure of butan-2-ol had been drawn.

(e) It was common for this not to be attempted. Candidates should ensure they have checked every page for questions by turning over every page.

CHEMISTRY

Paper 0620/42
Theory (Extended)

Key messages

Candidates must ensure they read questions carefully to ensure that the answer they give addresses what has been asked. Responses seen in **Question 2(d)(i)**, where electron arrangements were omitted and in **Question 3(c)(ii)**, where descriptions of reactions rather than observations were given, were typical examples where candidates did not read the question fully.

When drawing organic structures, candidates should be aware that structures require all bonds to be drawn and thus the valency of the atoms used need to be correct. Divalent hydrogen atoms and monovalent oxygen atoms were often seen.

When a chemical equation is asked for, this means a balanced symbol equation using correct symbols/formulae and not a word equation.

In questions where a stated number of responses is asked for, such as a single property, two (or three) properties should not be given as incorrect statements may contradict correct answers.

In extended questions, such as **Question 4(c)**, candidates are advised to present their answers in short, sharp sentences, even using bullet points. Long, rambling sentences often lead to omission of some facts and contradiction of others.

General comments

Most candidates appeared to be well prepared for this paper.

Better performing candidates attempted to show full working in the two calculation questions; this is good examination practice.

Very few candidates felt the need to write on extra pages. If candidates do need to write on extra pages the question they are answering must be clearly labelled.

Comments on specific questions

Question 1

(a) (i) Most candidates found this question straightforward and could name the changes of physical states. Sublimation proved the most difficult of the four terms for candidates to recall.

(ii) Most candidates were able to express a coherent answer to this straightforward question.

(iii) The temperature at which the processes take place was the expected answer. Most candidates were able to give a difference between boiling and evaporation by simply thinking about the processes. e.g. evaporation is a surface process; boiling has bubbles.

(b) Candidates who performed less well thought ‘separation’ required the name of a separation process, such as filtration or chromatography.

(c) Candidates knew the formula of a typical Group I oxide, whether expressed as X_2O or through use of an actual formula such as Li_2O. A relatively large proportion did not balance the correct species, whilst candidates who performed less well opted for $X_2 + O \rightarrow X_2O$.

Question 2

(a) The electron configuration of calcium was almost universally known.

(b) (i) The idea that the outer shell contains two electrons in the strontium atom was well known. This was often expressed as 'strontium has the same number of outer electrons (as calcium)'. Other suitable responses such as 'the same number of electrons in shell one', were accepted.

(ii) The difference in the arrangement of electrons was successfully answered by most of the candidates. Poor wording such as 'different numbers of outer shells' led to loss of marks.

(c) (i) Most candidates recognised the test for hydrogen; occasionally oxygen was seen.

(ii) The identity of the OH^- (hydroxide) ion as the cause of alkalinity was known by better performing candidates. Many candidates decided to give the identity of a second ion (usually Ca^{2+}). The question clearly asked for 'the ion responsible' so to give a second ion resulted in the mark being lost even if they had written OH^- as one of their choices.

(iii) Sensible answers such as pH 9 or 10 were expected. The response 'above 7' received no credit as this encompasses pH 13 and 14.

(iv) Many candidates scored both marks. A significant minority chose to give the word equation. No credit could be given for a word equation as a chemical equation was asked for.

(d) (i) Completion of the electron arrangement of ions in the diagram was not attempted by many candidates. Presumably these candidates assumed the electron configurations were complete, having glanced at the two chloride ions, both with a full outer octet. Closer inspection would have revealed that only two shells of electrons were shown, with the configuration 2,8, and thus a third shell is needed. The magnesium ion with two electrons in the (first) shell is also incomplete.

Those who did attempt to complete the electron arrangements invariably did so correctly.

The charges on the ions were known by most candidates, whether the electron configurations had been attempted or not.

(ii) Most candidates knew three physical properties of ionic compounds and were able to state high physical constants (such as melting point), solubility in water and electrical conductivity when molten (or aqueous) – or lack of conductivity when solid.

Some candidates gave vague phrases such as 'do not conduct electricity' in which they did not specify 'when solid', or 'conduct electricity' in which they did not specify 'when molten'. Others did not realise that 'high melting point' reflected the same property as 'high boiling point'.

Several candidates attempted to include an extra property – often putting a '4' underneath answer line 3. In many cases, this resulted in contradictory answers and candidates lost a mark.

(e) Candidates found giving the ionic equation for this precipitation reaction challenging. Most did not realise that formation of a solid precipitate comes about as a result of a reaction between two aqueous ions. Some candidates gained partial credit for realising that any two aqueous species would make one solid species; very few were able to give the correct formulae of the species.

Question 3

(a) The description of how the combustion of sulfur-containing fossil fuels leads to acid rain was generally well done. The idea of the formation of sulfur dioxide was well known as the first stage, prior to its reaction with water to produce acid rain. Many very good descriptions were seen. Some candidates did not identify the oxide of sulfur; others did not realise that sulfur needs to be oxidised initially. Other explanations such as 'reacts with water', 'dissolves in water' or 'combines with water' were accepted. 'Mixes with water' did not portray that the conversion of sulfur dioxide to acid rain was a chemical reaction.

(b) (i) Many candidates found writing a balanced symbol equation to be challenging. Nearly all candidates remembered that the symbol required to show the reversible nature of the reaction was $\rightleftharpoons$.

(ii) The essential conditions for the Contact process were known by most candidates. Errors included omitting the units on temperature (and sometimes pressure) and using an incorrect oxide of vanadium as the catalyst. In giving the conditions for the Contact process, many incorrectly opted to choose the conditions for the Haber process.

(iii) The conversion of sulfur trioxide to sulfuric acid was well known. Many opted to summarise this as the addition of water to sulfur trioxide.

(c) (i) Most candidates knew a measuring cylinder would be the ideal apparatus to use in this method. Volumetric apparatus such as burettes and pipettes were also acceptable.

(ii) Two observations indicating the reaction had finished were asked for. The expected responses were the ceasing of effervescence and appearance of a white solid (zinc carbonate) in the reaction mixture. Many candidates stated, 'when no more gas is given off', which did not receive credit as this does not explain how they would observe no more gas is given off. Other candidates suggested it was when all the zinc carbonate had dissolved, thus implying they had not understood the method being used.

(iii) Better performing candidates realised that excess carbonate needed to be added to react with (or remove) all the acid.

(iv) Many candidates struggled to explain the term *saturated solution*. Instead, descriptions of crystallisation and its associated methods were often seen. Candidates who performed less well wrote about a lack of double bonds.

(v) Many candidates left this question unanswered. Most of those who gave a state symbol assumed the zinc sulfate to be a solid. Very few realised that it was $ZnSO_4$(aq), which should have appeared in the equation.

(vi) Only a minority of candidates knew that zinc oxide (or hydroxide) would be a suitable starting zinc compound, which could be used to make zinc sulfate by this method. The most common response was zinc nitrate, closely followed by zinc chloride. This might suggest candidates were trying to name alternative salts of zinc, which could be made by the method given.

(vii) The insolubility of barium sulfate was known by many as the reason why it could not be prepared by this method. Many went on to give excellent descriptions of how any barium sulfate formed would form an impenetrable barrier on the surface of the barium carbonate. Others who simply stated that a precipitate would form, received no credit as a precipitate is a phenomenon seen when two solutions are mixed.

(d) (i) Most candidates knew the colour of methyl orange in alkali.

(ii) Many better performing candidates were able to deduce the concentration of the acid in mol / dm^3. Very few attempted to calculate the concentration in g / dm^3.

(e) Candidates found the calculation of percentage yield to be challenging. Some were able to calculate the number of moles of $FeSO_4$ at the start and many successfully determined the number of moles of Fe_2O_3 produced. Very few were able to determine the final outcome as a percentage.

Question 4

(a) (i) The majority of candidates realised that the graph indicated a decrease in rate of reaction due to a decrease in gradient.

(ii) The reasons given for the decrease in rate of reaction seldom included the key point of the concentration of the acid decreasing.

(iii) Nearly all candidates gave 120 seconds as the finishing time. Errors came as a result of mis-reading the point at which the curve became a straight, horizontal line. Some candidates did not understand what the graph represented and opted for 240 second (the highest time value on the *x*-axis).

(b) Nearly all candidates realised smaller pieces of marble would give a quicker reaction and so gave a steeper initial start to the graph. A large proportion did not realise that as the acid was the limiting factor, then the final volume would be identical.

(c) The effect on the time taken, 'time is decreased', was often completely ignored by candidates. Others gave statements such as 'the reaction would be faster', but this is a description of the change in rate, not the change in time.

Most candidates appreciated that particles would increase in energy and thus move faster, leading to an increase in the frequency of collisions.

The mistake made by nearly all candidates who had got this far was to go on to say 'therefore there is an increase in the frequency of successful collisions'. This gets no credit as, for example, if at any one time 10% of collisions have enough energy to allow a reaction to occur, then if the overall rate of collisions increases (e.g. doubles), it is still only 10% (i.e. the same proportion) of this higher (doubled) rate of collisions which bring about a reaction. This would explain why if the concentration of a reactant is doubled then the rate of reaction doubles. Frequency of all collisions doubles and therefore frequency of the 10% of successful collisions must also double.

The key point about increasing the energy of reacting particles is that a *greater proportion* of the collisions now have enough energy to allow a reaction to occur. So, although the rate of collisions may be doubled through greater speed of particles, far more than 10% of these collisions will now have enough energy to allow a reaction to occur.

Question 5

(a) Most candidates knew either the formula of the third member (C_4H_6) or the name of the second member of the alkynes. Care was needed in the spelling of the name to ensure there was no confusion between an alkyne suffix and an alkene suffix.

(b) The covalent bonding of ethyne was generally well done. A significant proportion of candidates decided to make the carbon-carbon connection a double bond (despite a triple bond being drawn in the table).

(c) (i) The properties of a homologous series were well known. Several candidates ignored the question requirements, which told candidates that compounds in the same homologous series have the same general formula and asked them to give two other characteristics. These candidates repeated the information in the question and wrote 'same general formula' as an answer.

Some candidates wrote a third characteristic. Occasionally a wrong (third) characteristic was given, this losing a mark.

(ii) Many candidates deduced the correct general formula of alkynes. C_nH_{2n} – 2 was not allowed where the '2' was clearly large and above the line.

(d) The test for unsaturation was well known.

(e) (i) Candidates found this question challenging and many could not name the oxidising agent.

(ii) The structure of ethanoic acid showing all bonds was well drawn. Better performing candidates included the bond between the O and H in the –O–H bond.

(f) (i) The name of the ester was well known and generally, the correct structure was drawn. Methyl groups were often drawn as $–CH_3$, rather than in expanded form showing every bond.

(ii) If candidates knew the name of the ester in **(i)**, they invariably knew the name of an isomer.

(g) (i) The majority of candidate knew this was condensation polymerisation. 'Addition' was not an uncommon answer.

(ii) *Terylene* was quite well known, with 'nylon' given from some candidates. Candidates should take care with the spelling of compound names.

CHEMISTRY

Paper 0620/43
Theory (Extended)

Key messages

Candidates should learn the meanings and definitions of common words and phrases specified on the syllabus.

Candidates should be aware that electrolysis of aqueous solutions using inert electrodes can produce either oxygen or a halogen at the anode (+) and hydrogen or a metallic element at the cathode (–).

Many candidates find writing correct formulae of chemical compounds to be challenging. This is an essential skill in chemistry. Formulae of compounds of univalent metals, such as sodium, are a particular area that requires attention.

Candidates must ensure they read questions carefully to ensure that the answer they give addresses what has been asked.

General comments

Very few candidates felt the need to write on extra pages. If candidates do need to write on extra pages the question they are answering must be clearly labelled.

Comments on specific questions

Question 1

Candidates answered all parts to **Question 1** extremely well. There were a small number of common errors as shown below.

(a) Hematite was seen occasionally.

(b) Bauxite was the most common incorrect answer.

(c) This part was the least well answered. Ammonia and sodium chloride were seen occasionally.

(d) Sulfur dioxide was seen occasionally.

(e) This was almost always correct.

(f) This was answered very well.

(g) and **(h)**
These parts were both answered extremely well. Carbon dioxide and oxygen were occasionally interchanged.

Question 2

(a) (i) This was answered reasonably well. Electrolysis is the name given to the type of chemical reaction in which an ionic compound when molten or in aqueous solution is decomposed by electricity. It is advisable to avoid using the word ‘separate’ when explaining electrolysis. ‘Splitting’ and ‘breaking’ are inadequate alternatives to decomposition.

(ii) This was answered well. Electron was a more common correct answer than ion. Answers other than types of particles, such as anode, electrode and electrolyte were occasionally seen.

(b) (i) Inert means that a substance does not undergo chemical reactions. 'Not very reactive' or 'low reactivity' both suggest that a substance does react but not very well; both these responses were inadequate. 'Good conductor' or 'conductor' had to be qualified by reference to electricity in order to gain credit.

(ii) This was answered reasonably well. Effervescence, fizzing or bubbling was often missing from the description of the gas give off at the anode.

Copper was occasionally identified by its colour without reference to it being a solid. Copper was occasionally described as blue or black.

Question 3

(a) This was answered correctly by the vast majority of candidates.

(b) This was answered correctly by the majority of candidates. A common error was $151 \div 431 \cdot 100 = 35\%$.

(c) Better responses stated that SnO_2 would be the better choice as it contained the higher percentage of tin. Some candidates ignored the instruction to 'Use this information and your answer to **(b)**'. Reference to percentage was often missing from the suggestion given. Yield and impurities were often seen as alternatives to the correct answer.

(d) Although given in previous parts of the question, a formula other than SnO_2 was occasionally seen; Sn_2O_4 and SnO_4 were common. SnO was often seen as a product instead of Sn. The other product was sometimes seen as CO_2 instead of CO.

(e) More reactive metals will displace less reactive ones, leading to a reaction in both cases. Many candidates gave 'no reaction' at least once. Non-existent substances, mainly those containing two metals, were often seen; these included SnCu, FeSn, Sn_2Cu and Fe_2Sn.

(f) (i) This was answered very well by the majority of candidates.

(ii) Candidates found this a challenging question. The syllabus requires them to be able to describe the action of heat on nitrates of listed metals; these metals include copper. Only a small number of candidates knew the name and appearance of nitrogen dioxide. Nitrogen and ammonia were commonly seen.

(iii) There were a small number of correct answers to this question.

(g) (i) When zinc completely coats iron, the iron cannot come into contact with air and water and therefore rusting cannot occur. The relative reactivities of zinc and iron are irrelevant unless the zinc is scratched. There was a tendency for candidates to ignore the fact that the iron was 'completely coated'.

(ii) The fact that zinc is more reactive than iron was seen more often than a reference to loss of electrons by zinc. If candidates mentioned that zinc loses electrons, they often followed this by the incorrect statement that 'zinc rusts'.

When the zinc is scratched many candidates were under the impression that the zinc continues to act as a barrier.

Question 4

(a) This was answered fairly well. Common errors seen were not using the mole ratio, the use of relative molecular masses and the use of 24 dm^3.

(b) There were some extremely good answers from candidates who had prepared very well for this type of question.

Some candidates gave a full description of the titration with the indicator, even though this had been described already in the question and was unnecessary. Some described removal of the indicator by fractional distillation. Evaporation to dryness was only seen occasionally. Some stated that the crystals should be dry, which was given in the question, without giving details of how drying should be carried out.

(c) (i) Only a small number of candidates gave two correct observations. Effervescence was seen more often than a correct statement of the magnesium ribbon disappearing. Candidates were told that solution **X** was in excess, which informs candidates that all the magnesium reacts. Some candidates incorrectly stated that a precipitate would form.

(ii) This was answered correctly by a large number of candidates. A variety of incorrect colours were occasionally seen.

(iii) 'An aqueous solution containing barium ions' may have been an unfamiliar phrase to some candidates. This is the phrase used as the test for sulfate ions on the syllabus.

(d) Many candidates found writing formulae challenging. A small number wrote word equations.

(i) The formula of magnesium hydroxide was often seen as MgOH.

(ii) Candidates answered this correctly more often than the other parts of **(d)**.

(iii) The formulae of sodium carbonate and sodium sulfate were regularly seen as $NaCO_3$ and $NaSO_4$.

Question 5

(a) Measurement of volume of gas and time were required. Incorrect answers such as 'the reading on the gas syringe, the amount of gas and how long the reaction took', as well as unnecessary measurements such as 'mass of calcium carbonate, volume of hydrochloric acid and temperature' were often seen.

(b) Very few candidates stated that the rate of reaction decreased as the reaction proceeded. Most thought that the rate increased. Reference to decrease of concentration of hydrochloric acid and an explanation in terms of fewer collisions per unit time was not seen very often. Collisions were only occasionally mentioned.

(c) Many candidates knew that particles would gain energy and therefore move faster; only a small number referred to kinetic energy. Increase in number of collisions per unit time was seen much more often than in **(b)**. A correct reference to activation energy/successful collisions was rarely seen. Statements such as 'particles have more activation energy' and 'particles have the activation energy' were common responses that did not gain credit.

(d) This was answered well by large numbers of candidates. Only reactions between gases have an increased rate if pressure is increased. Concentration and surface area were sometimes given without reference to increase in either case.

Question 6

(a) (i) There were some excellent answers to this question. Generic terms such as sugars, carbohydrates and alkenes were sometimes seen as an attempt to identify the reactants. Specific names of chemical compounds were required.

The equation for fermentation was sometimes unbalanced.

The temperature of hydration was frequently incorrect. The reaction is generally conducted at 300°C. Temperatures much higher than this were often seen.

(ii) Candidates found this question challenging. Some candidates referred to renewable resources. Other comments such as cheap, without a clarifying explanation, easy and environmentally friendly were common.

(iii) Solvent and fuel are listed on the syllabus and were often seen. Vague answers such as 'for alcohol, consumption, medical and industrial' were common.

(b) (i) The only polymer without an ester or amide linkage was only recognised occasionally.

(ii) Candidates answered this correctly more often than the other parts of **(b)**.

(iii) This was answered quite well.

(iv) *Terylene* was not well known.

(v) The complex carbohydrate was the only one to have the –O– linkage. Candidates found this to be the most difficult to identify.

CHEMISTRY

Paper 0620/51
Practical Test

Key messages

Graphs - Candidates should be encouraged to check their plotting of points. A good method is to read the values of each point plotted from their graph and compare them to their data in the table of results.
There is a tendency to describe precipitates as cloudy or milky solids.
Candidates should be aware that the mark allocation reflects the number of valid points to be made for parts of questions.
Candidates need to be aware that in experimental plans, details should be given of each step and also to identify the apparatus used in each step. The latter is best done within the plan as part of each step, rather than as a list. Candidates who give a list of apparatus, often do not clearly state the use of each item of apparatus.

General comments

The majority of candidates successfully completed the questions and there was no evidence that candidates were short of time.

Supervisors reported very few problems with the requirements of this practical examination. It is essential that centres followed the confidential instructions carefully. In this case, the hydrogen peroxide should have been newly purchased.

A small number of centres reported times for **Question 1** that were greater than expected, leading to problems with plotting the graph in **Question 1(b)**. A scaling factor was employed to compensate for these issues.

The Examiners used the Supervisors' results for **Questions 1** and **2** when marking the scripts to check comparability.

Comments on specific questions

Question 1

(a) All of the candidates carried out the four experiments. The table of results was generally fully and successfully completed. It was common for the final temperatures to be greater than the initial temperatures. This suggests that some candidates did not stir the mixture after heating prior to measuring the temperature. Most average temperatures recorded were correct; some were wrong and not between the initial and final temperatures recorded. The vast majority of candidates obtained the expected results with times decreasing as the temperature increased. A minority of results were recorded in minutes and seconds rather than just seconds as in the table.

(b) Most candidates plotted the four points correctly; sometimes the scales on the two axes were different. This resulted in some candidates making errors with some of their plotting. Many good smooth line-graphs were seen. A few candidates were penalised for multiple lines, which were clearly not best fit.

(c) This was generally well-answered. Common errors were to read from 60 °C instead of 60 s, misreading the graph scale and missing out or giving incorrect units.

(d) (i) Despite the expected times being recorded in the table, the experiment that involved the greatest rate of reaction was sometimes incorrectly identified.

(ii) Most candidates correctly stated that at a higher temperature the particles had more energy and so moved faster. Better answers then related this to an increased frequency of collisions. Reference to just 'more collisions' was insufficient. Stating that reactions are faster at higher temperatures is not an explanation.

(e) Vague answers referring to the use of a burette or pipette showed that candidates had not read the question. Good responses based on insulation to reduce heat losses were rare. Repeating the experiments and taking an average was a common correct answer but full credit was only awarded for indicating that this would reduce errors and anomalous results.

(f) Better performing candidates gave excellent answers explaining that the slow rate of addition from a burette would cause a problem with the timing of the experiment.

Weaker responses did not realise that the rate of addition would be slow and gave answers based on measuring cylinders being as accurate, or even more accurate, than a burette.

Question 2

This question was generally well answered by candidates who gave details of all observations and recorded them accurately.

Solid **P** was lithium nitrate.
Solid **Q** was manganese(II) chloride.

(a) A majority of candidates correctly reported the appearance of the two solids as white and pink respectively. A small number got the solids mixed up and so swapped the colours over.

(b) (i) This was generally well answered. Most candidates recorded the expected colour change of an indicator and described the pungent smell of the gas. References to splints and limewater were prevalent and ignored.

(ii) Ammonia was identified by most candidates; some guesses, such as carbon dioxide and oxygen, were evident.

(c) (i) A significant number of candidates observed the formation of a white precipitate or fizzing. This scored no credit as no reaction or no precipitate was the expected observation, as solid **P** was not a sulfate.

(ii) Some candidates decided that as they had carried out a sulfate test that the solid must be a sulfate, despite no reaction being observed in **(c)(i)**. A common incorrect answer was to state that the substance was not a halide.

(d) Many candidates are now familiar with carrying out a flame test and most observed a red flame. Some candidates recorded two colours, which was penalised.

(e) Solid **P** was often correctly identified; some just wrote 'lithium' and did not consider the tests carried out before the flame test.

(f) Many candidates reported that bubbling was seen but did not state that the solid had melted or turned into a liquid. Various colour changes were reported; it was common for candidates to miss the fact that the solid became paler, or white, early in the heating process.

(g) (i) A minority of candidates correctly recorded the observation that a beige precipitate was formed, which darkened on standing. The majority of candidates did not report all observations or follow the instructions. The most common error was to state just one colour of precipitate and this meant it was not clear if this colour was the initial colour or the one formed after standing for 5 minutes.

(ii) Many candidates would not commit themselves and gave two colours such as cream, white, or yellow. In the halide tests provided in the qualitative analysis notes, the colour expected will be white or cream or yellow. Hence, only one colour will be accepted.

(h) One mark was awarded for concluding that the tests on solid **Q** indicated the presence of chloride ions. Full credit was only scored by understanding that as the compound was coloured, it contained a transition metal – some suggested cobalt or manganese. Many incorrectly stated iron(III) ions were present from **(g)(i)**, which showed a lack of practical experience with qualitative analysis.

Question 3

Information was given about three substances in a mixture. The aim was to plan an experiment to obtain a sample of each substance from the mixture.

The most common approach was to perform filtration, followed by distillation. Using this method, it was common for candidates to wash the residue obtained from filtration, i.e. sodium carbonate, with water. Candidates should be aware that washing a water-soluble substance with water will result in it dissolving.

The filtrate, which was a mixture of ethanol and limonene, was then separated by (fractional) distillation. Some candidates seemed to describe the industrial rather than the laboratory process, stating that the two liquids would be obtained at different heights. Some good detailed answers were seen involving descriptions of heating the liquid mixture and collecting the ethanol at 78 °C using a condenser.

Some heated the mixture first to separate the two liquids, which then remained in the flask.

CHEMISTRY

Paper 0620/52
Practical Test

Key messages

- Graphs - Candidates should be encouraged to check their plotting of points. A good method is to read the values of each point plotted from their graph and compare them to their data in the table of results.
- Plotted points on a grid should be clearly visible e.g. crosses. Smooth line-graphs should be curves with no straight-line sections drawn with a ruler.
- Lists of answers with correct and incorrect responses are penalised if contradictory. For example, if the correct answer is precipitate dissolves/is soluble and a candidate writes 'precipitate dissolves and a white solid forms', no mark will be awarded.
- There is a tendency to describe precipitates as cloudy or milky solids.
- Candidates should be aware that the mark allocation reflects the number of valid points to be made for parts of questions.
- Candidates need to be aware that in experimental plans, details should be given of each step and also to identify the apparatus used in each step. The latter is best done within the plan as part of each step, rather than as a list. Candidates who give a list of apparatus, often do not clearly state the use of each item of apparatus.

General comments

There was no evidence of candidates running out of time in this practical examination. The vast majority of candidates successfully attempted all of the questions. The full range of marks was seen.

It is essential that centres followed the confidential instructions carefully. In this case, the hydrogen peroxide should have been newly purchased.

Most candidates were able to gain the expected results in **Question 1**, with the times in ascending order from Experiments 1 to 5. A small number of centres reported times for **Question 1** that were greater than expected, leading to problems with plotting the graph in **Question 1(b)**. A scaling factor was employed to compensate for these issues.

Candidates found the last question, **Question 3**, less demanding than in previous years.

Comments on specific questions

Question 1

(a) The table of results was often completed correctly. One error was completing the times for the experiments in minutes and seconds.

(b) Most candidates plotted the points correctly but often not clearly. Poor smooth line-graphs were evident. Some candidates drew a straight line with a ruler when the smooth line graph was clearly a curve.

(c) Candidates should be encouraged to show clear construction lines on the graph and ensure that these lines are parallel to the axes. A significant number of candidates did not show clearly on the grid how they worked out their answer. Others omitted the unit or gave the wrong unit.

(d) (i) This was generally correctly answered with Experiment 1 given.

(ii) Better performing candidates were capable of explaining that the rate of reaction was greatest because of the higher concentration of solution **L** or that more particles were present with the resultant increased chance or frequency of collisions. Reference to just more collisions did not score credit for the second marking point. Some answers mentioned the increased kinetic energy or speed of the particles which was penalised. Many responses just referred to less time of reaction and scored no credit.

(e) (i) Most candidates understood that using a graduated pipette to measure the volume of solution **L** would be more accurate.

(ii) Some candidates appreciated that using a pipette would be slower; only a minority realised that this would introduce a timing error. Vague responses such as 'a pipette is harder/difficult to use' were seen. Several candidates thought that a pipette could only measure a single value and would therefore have to be refilled more than once.

(f) The idea of repeating the experiments was common but many did not mention any comparison or averaging of results. The use of a burette instead of a pipette or keeping the volumes constant were suggestions that showed a lack of understanding.

Question 2

Solid **N** was ammonium sulfate.

Solid **O** was potassium chloride,

(a) This was well answered with the correct description of the two white solids. A number of candidates wrongly described the solids as clear or colourless. References to precipitates were penalised.

(b) This was generally well-answered. The mark allocation indicated that three different observations were expected and many candidates only gave one or two. Expected observations were the solid melting or turning into a liquid, condensation or sublimation and indicator paper changing colour.

(c) The expected observation was white precipitate formed and this was recorded by the majority of candidates.

(d) The majority of candidates tested the gas with litmus paper, which turned blue. Credit was awarded for reference to a pungent smell but identifying ammonia was ignored as the name of a gas is not an observation.

(e) Most candidates identified the gas as ammonia.

(f) Most candidates identified solid **N** as ammonium sulfate though aluminium and chloride were common alternative wrong answers.

(g) The expected observation was no change or no precipitate formed. Any indication of a change was penalised.

(h) The expected observation was white precipitate formed. Many candidates would not commit themselves and gave two colours such as cream, white, or yellow. In the halide tests provided in the qualitative analysis notes, the colour expected will be white or cream or yellow. Hence, only one colour will be accepted.

(i) Many candidates are familiar with carrying out a flame test and most observed a lilac flame. Some candidates recorded two colours which was penalised.

(j) Solid **O** was often correctly identified as potassium chloride. Despite the correct observations to the tests some candidates did not use the qualitative analysis notes given to help identify the solid **B**.

Question 3

The complete range of marks was seen in this planning question. Many candidates produced excellent answers and scored full credit. A number of candidates did not attempt the question. Other candidates scored partial credit but often did not answer the two questions:

- which reaction is exothermic and which is endothermic
- which energy change is greater?

Common errors were substituting named substances for **C** and **D**, adding water instead of acid and not detailing quantitative aspects of the investigation. Not measuring the volume of the acid or the masses of the solids showed a lack of planning. Measuring the temperature of the solids showed a lack of practical experience.

The use of heat in the investigation showed a lack of knowledge and understanding and was penalised.

There was evidence of confusion between the terms *exothermic* and *endothermic*. One misunderstanding is that endothermic reactions cause a temperature rise because of the sign of the enthalpy change, or if the temperature change were negative that would indicate an exothermic reaction.

Difficulties were encountered relating the temperature difference to the largest energy change. Some candidates thought that the magnitude or rate of temperature change was a guide to the exothermic nature of the reaction.

Candidates obtained marks for four of the following points:

- measured volume of dilute hydrochloric acid
- use of suitable container
- initial temperature of acid
- add known mass of solid **C**
- final temperature/change in temperature
- repeat with solid **D**.

Two marks were awarded for correct conclusions answering the two questions.

CHEMISTRY

Paper 0620/53
Practical Test

Key messages

Graphs - Candidates should be encouraged to check their plotting of points. A good method is to read the values of each point plotted from their graph and compare them to their data in the table of results.
There is a tendency to describe precipitates as cloudy or milky solids.
Candidates should be aware that the mark allocation reflects the number of valid points to be made for parts of questions.
Candidates need to be aware that in experimental plans, details should be given of each step and also to identify the apparatus used in each step. The latter is best done within the plan as part of each step, rather than as a list. Candidates who give a list of apparatus, often do not clearly state the use of each item of apparatus.

General comments

The majority of candidates successfully completed the questions and there was no evidence that candidates were short of time.

Supervisors reported very few problems with the requirements of this practical examination. It is essential that centres followed the confidential instructions carefully. In this case, the hydrogen peroxide should have been newly purchased.

A small number of centres reported times for **Question 1** that were greater than expected, leading to problems with plotting the graph in **Question 1(b)**. A scaling factor was employed to compensate for these issues.

The Examiners used the Supervisors' results for **Questions 1** and **2** when marking the scripts to check comparability.

Comments on specific questions

Question 1

(a) All of the candidates carried out the four experiments. The table of results was generally fully and successfully completed. It was common for the final temperatures to be greater than the initial temperatures. This suggests that some candidates did not stir the mixture after heating prior to measuring the temperature. Most average temperatures recorded were correct; some were wrong and not between the initial and final temperatures recorded. The vast majority of candidates obtained the expected results with times decreasing as the temperature increased. A minority of results were recorded in minutes and seconds rather than just seconds as in the table.

(b) Most candidates plotted the four points correctly; sometimes the scales on the two axes were different. This resulted in some candidates making errors with some of their plotting. Many good smooth line-graphs were seen. A few candidates were penalised for multiple lines, which were clearly not best fit.

(c) This was generally well-answered. Common errors were to read from 60 °C instead of 60 s, misreading the graph scale and missing out or giving incorrect units.

(d)(i) Despite the expected times being recorded in the table, the experiment that involved the greatest rate of reaction was sometimes incorrectly identified.

(ii) Most candidates correctly stated that at a higher temperature the particles had more energy and so moved faster. Better answers then related this to an increased frequency of collisions. Reference to just 'more collisions' was insufficient. Stating that reactions are faster at higher temperatures is not an explanation.

(e) Vague answers referring to the use of a burette or pipette showed that candidates had not read the question. Good responses based on insulation to reduce heat losses were rare. Repeating the experiments and taking an average was a common correct answer but full credit was only awarded for indicating that this would reduce errors and anomalous results.

(f) Better performing candidates gave excellent answers explaining that the slow rate of addition from a burette would cause a problem with the timing of the experiment.

Weaker responses did not realise that the rate of addition would be slow and gave answers based on measuring cylinders being as accurate, or even more accurate, than a burette.

Question 2

This question was generally well answered by candidates who gave details of all observations and recorded them accurately.

Solid **P** was lithium nitrate.
Solid **Q** was manganese(II) chloride.

(a) A majority of candidates correctly reported the appearance of the two solids as white and pink respectively. A small number got the solids mixed up and so swapped the colours over.

(b) (i) This was generally well answered. Most candidates recorded the expected colour change of an indicator and described the pungent smell of the gas. References to splints and limewater were prevalent and ignored.

(ii) Ammonia was identified by most candidates; some guesses, such as carbon dioxide and oxygen, were evident.

(c) (i) A significant number of candidates observed the formation of a white precipitate or fizzing. This scored no credit as no reaction or no precipitate was the expected observation, as solid **P** was not a sulfate.

(ii) Some candidates decided that as they had carried out a sulfate test that the solid must be a sulfate, despite no reaction being observed in **(c)(i)**. A common incorrect answer was to state that the substance was not a halide.

(d) Many candidates are now familiar with carrying out a flame test and most observed a red flame. Some candidates recorded two colours, which was penalised.

(e) Solid **P** was often correctly identified; some just wrote 'lithium' and did not consider the tests carried out before the flame test.

(f) Many candidates reported that bubbling was seen but did not state that the solid had melted or turned into a liquid. Various colour changes were reported; it was common for candidates to miss the fact that the solid became paler, or white, early in the heating process.

(g) (i) A minority of candidates correctly recorded the observation that a beige precipitate was formed, which darkened on standing. The majority of candidates did not report all observations or follow the instructions. The most common error was to state just one colour of precipitate and this meant it was not clear if this colour was the initial colour or the one formed after standing for 5 minutes.

(ii) Many candidates would not commit themselves and gave two colours such as cream, white, or yellow. In the halide tests provided in the qualitative analysis notes, the colour expected will be white or cream or yellow. Hence, only one colour will be accepted.

(h) One mark was awarded for concluding that the tests on solid **Q** indicated the presence of chloride ions. Full credit was only scored by understanding that as the compound was coloured, it contained a transition metal – some suggested cobalt or manganese. Many incorrectly stated iron(III) ions were present from **(g)(i)**, which showed a lack of practical experience with qualitative analysis.

Question 3

Information was given about three substances in a mixture. The aim was to plan an experiment to obtain a sample of each substance from the mixture.

The most common approach was to perform filtration, followed by distillation. Using this method, it was common for candidates to wash the residue obtained from filtration, i.e. sodium carbonate, with water. Candidates should be aware that washing a water-soluble substance with water will result in it dissolving.

The filtrate, which was a mixture of ethanol and limonene, was then separated by (fractional) distillation. Some candidates seemed to describe the industrial rather than the laboratory process, stating that the two liquids would be obtained at different heights. Some good detailed answers were seen involving descriptions of heating the liquid mixture and collecting the ethanol at 78 °C using a condenser.

Some heated the mixture first to separate the two liquids, which then remained in the flask.

CHEMISTRY

Paper 0620/61
Alternative to Practical

Key messages

Candidates should use a sharp pencil for clearly plotting points and for drawing their lines of best fit on their graphs. This allows them to correct any errors. The question might require the line of best fit to be a curve or a straight line, as appropriate. Straight lines should be drawn with a ruler, but rulers should not be used to join the points on a curve. Lines of best fit should avoid anomalous points.
There is a tendency to describe white precipitates as cloudy or milky solids.
Candidates should be aware that the mark allocation reflects the number of valid points to be made for parts of questions.
Candidates should be prepared to answer questions requiring the planning of an investigation and the idea of a fair test. Numerous past paper 6s have examples of these questions.

General comments

The majority of candidates attempted all of the questions. A significant minority left many questions unattempted. The full range of marks was seen. Some candidates were not well prepared for this examination and showed a lack of experience with knowledge of practical procedures. The paper discriminated successfully between candidates of different abilities but was accessible to all.

Candidates found **Questions 1** and **4** to be the most demanding.

Comments on specific questions

Question 1

(a) A minority of candidates scored both marks for identifying the correct order. A number of answers indicated that rinsing the sand with water in a filter funnel was carried out before filtration, which showed a lack of understanding.

(b) Correct references to evaporating dish/basin were seen. Crucible, Petri dish and bowl were common incorrect answers.

(c) Better responses realised that the rinsing of the sand with water was to remove any sodium chloride. Vague responses lacked detail and referred to removal of impurities.

(d) Filtration was well known.

(e) Most methods described were unsuitable to check for the purity of sodium chloride e.g. flame tests, pH tests and crystallisation. A minority realised that the melting point could be determined. The use of checking the boiling point showed a lack of understanding of the state of the sodium chloride.

Question 2

(a) The masses in the tables of results were completed correctly from the balance diagrams by the majority of the candidates. All readings should be given to one decimal place e.g. 86.0. The reading at 2 minutes was sometimes recorded as 84.2 instead of 84.1.

Some candidates did not read the table carefully and did not record the **total** loss of mass as requested after each minute.

(b) Most candidates plotted the points for both experiments on the grid correctly. Points were sometimes plotted wrongly because the scale on the *y*-axis was misread. Some graphs were not smooth lines and the use of a ruler to join the points dot to dot was penalised.

(c) Most candidates worked out the total loss of mass after 30 seconds and worked out the average rate of the reaction at that time. Some errors in the calculation were seen.

(d) Repeating the experiment with powdered solid instead of lumps of solid would result in a faster reaction and many sketches showed this with a steeper curve than the original. The use of excess solid would result in the same total loss in mass and therefore the sketch curve would end at the same level. Many sketch curves did not end at the same level.

(e) (i) This was well answered with the idea of escape of gas or carbon dioxide commonly given. Vague references to the solid dissolving/reacting were prevalent.

(ii) The purpose of the cotton wool was only recognised by better performing candidates, in terms of preventing the loss of acid and also allowing the gas to escape. Many answers referred to preventing the gas escaping having described the gas escaping in **(i)**. A common misconception was to stop air or other gases entering the flask which showed a lack of understanding.

(iii) The graph levelled off because the reaction finished. Numerous answers referred to the magnesium carbonate being all used up, despite having been informed that it was in excess. Credit was given for understanding that the nitric acid had all reacted.

(f) Most correct responses referred to the advantage of using a burette instead of a measuring cylinder as accuracy. The disadvantage was a good discriminating question. Some candidates appreciated that using a pipette would be slower. Vague responses such as 'a pipette is harder/difficult to use' were seen. Several candidates thought that a pipette could only measure small volumes and would therefore have to be refilled more than once.

Question 3

(a) Better performing candidates realised that the colour change of the potassium manganate(VII) indicated that sulfur dioxide gas was present. Confused answers discussed the presence of ammonia or chlorine, or identified the gas as sulfite.

(b) Many candidates were familiar with the flame test and deduced that solid **G** was a potassium compound. Only a minority correctly identified potassium and sulfite; sulfide and chloride were common.

(c) (i) and **(ii)**
Many responses showed that candidates had experienced this test and therefore observations were correct. A white precipitate, which was insoluble when excess aqueous sodium hydroxide was added was expected.

(d) This was generally well answered with the recognition of no precipitate with excess aqueous ammonia. Some candidates noted the formation of a white precipitate, which was penalised.

(e) Better performing candidates realised that there would be no reaction or no change as halide ions were not present.

(f) Some candidates realised that ammonia was produced but did not give a test and the expected observations. Credit was awarded for litmus turning blue and reference to a pungent smell.

Question 4

Some candidates were ill prepared for this planning question and did not attempt it.

A range of marks was seen. A large number of responses scored low marks due to a lack of detail e.g. 'add the paint to the solvents' with no mention of quantities of reactants or apparatus or the idea of a fair test. A significant number of answers referred to the addition of paint to cloth, paper and other surfaces, which showed a lack of understanding of the stem of the question which provided glass slides.

Good answers included the following points:

- applying paint to glass slides
- allowing paint to dry
- adding controlled amount of propanone
- until paint removed
- note amount of solvent added
- repeat with other solvent i.e. ethyl ethanoate
- conclusion/comparison.

Methods involving adding solvents to weighed painted slides and measuring the decrease in mass after a fixed time interval were awarded marks similarly.

CHEMISTRY

Paper 0620/62
Alternative to Practical

Key messages

Graphs - points should be clearly plotted with crosses; very small dots are not suitable. Straight line-graphs should not be drawn when a smooth line graph is requested.
Questions requiring candidates to plan an investigation should be answered with details of apparatus to be used, substances involved and quantitative practical procedures clearly specified. The questions relating to the investigation should be clearly answered.
Preliminary notes are advisable before writing the plan.

General comments

The majority of candidates successfully completed all questions and there was no evidence that candidates were short of time. The complete range of marks was seen with some candidates scoring very high marks.

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

Some candidates showed evidence of having little practical laboratory experience. This was particularly evident in **Question 1**.

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**.

Candidates found **Question 4** to be the most demanding.

Comments on specific questions

Question 1

(a) Credit was awarded for naming the apparatus as tongs. A significant number of candidates named them as forceps, scissors or tweezers, which was not accepted.

(b) Some candidates described the appearance of the product wrongly as 'black'. Others did not read the question and discussed the reaction that occurred, with white/bright flames being common. A lack of detail was evident and 'white' was insufficient as white solid or ash was the full description required.

(c) Magnesium oxide was very well known and understood. A minority of candidates showed a lack of understanding, referring to the presence of carbon dioxide.

(d) Good answers showed an understanding that the product was heated to increase the speed of reaction or dissolving of the magnesium oxide in water. Common wrong answers were concerned with removing impurities or crystallisation.

(e) This was generally well answered.

(f) Candidates seemed not to recognise the vulnerability of eyes when carrying out this experiment and the consequent need for goggles. The use of gloves, nose masks and fume cupboards to avoid breathing in the fumes were common misconceptions.

Question 2

(a) Almost all candidates completed the table of results. A minority of candidates incorrectly recorded the time for Experiments 4 and 5 in minutes instead of seconds. Some gave times of 5 and 51 for these experiments by ignoring the minute hand.

(b) Most candidates plotted all points correctly. A common plotting error was 111 s usually at 101 s. Most curves were good attempts and dot to dot straight lines drawn with a ruler were rare. Some candidates drew a best-fit straight line when a smooth curve was the obvious choice.

(c) Many candidates clearly indicated on their graph and showed clearly where they had read their answer from the grid. Some candidates misread their scale on the *y*-axis. A minority gave no unit or the wrong unit.

(d) (i) This was generally correctly answered, with Experiment 1 given.

(ii) Better performing candidates were capable of explaining that the rate of reaction was greatest because of the higher concentration of solution **L**, or that more particles were present with the resultant increased chance or frequency of collisions. Reference to just more collisions was not sufficient for the second marking point. Some answers mentioned the increased kinetic energy or speed of the particles, which was penalised. Many responses just referred to less time of reaction and scored no credit.

(e) (i) Most candidates understood that using a graduated pipette to measure the volume of solution **L** would be more accurate.

(ii) Some candidates appreciated that using a pipette would be slower; only a minority realised that this would introduce a timing error. Vague responses such as ‘a pipette is harder/difficult to use’ were seen. Several candidates thought that a pipette could only measure a single value and would therefore have to be refilled more than once.

(f) The idea of repeating the experiments was common but many did not mention any comparison or averaging of results. The use of a burette instead of a pipette or keeping the volumes constant were suggestions that showed a lack of understanding.

Question 3

(a) The majority of candidates correctly stated that the solid was white. References to colourless and yellow were common and scored no credit. Some candidates describe solid **N** as a precipitate or as a solution.

(b) The majority of candidates reported the formation of a white precipitate. Some confused answers referred to the precipitate dissolving.

(c) This was well answered with the use of litmus paper turning blue recognised and often a good description of a pungent smell. The formation of a white precipitate was often wrongly described.

(d) Many candidates correctly identified the gas produced as ammonia, but there was some confusion between ammoni**a** and ammoni**um.**

(e) Many candidates showed a lack of understanding regarding this negative test involving aqueous sodium hydroxide. Common incorrect answers referred to solid **O** being less reactive than sodium or that no cation was present. Correct reasoning resulted in credit for identifying a non-transition metal cation, or a named metal that would not form an insoluble hydroxide precipitate e.g. ‘calcium; a Group I cation present’ was an excellent answer.

(f) Many candidates correctly identified the presence of potassium in solid **O** from the flame test. A number did not recognise the presence of chloride ions from the result of the halide test.

Question 4

The complete range of marks was seen in this planning question. Many candidates produced excellent answers and scored full credit. Other candidates scored partial credit but often did not answer the two questions:

- which reaction is exothermic and which is endothermic
- which energy change is greater?

Common errors were substituting named substances for **C** and **D**, adding water instead of acid and not detailing quantitative aspects of the investigation. Not measuring the volume of the acid or the masses of the solids showed a lack of planning. Measuring the temperature of the solids showed a lack of practical experience.

The use of heat in the investigation showed a lack of knowledge and understanding and was penalised.

There was evidence of confusion between the terms *exothermic* and *endothermic*. One misunderstanding is that endothermic reactions cause a temperature rise because of the sign of the enthalpy change, or if the temperature change were negative that would indicate an exothermic reaction.

Difficulties were encountered relating the temperature difference to the largest energy change. Some candidates thought that the magnitude or rate of temperature change was a guide to the exothermic nature of the reaction.

Candidates obtained marks for four of the following points:

- measured volume of dilute hydrochloric acid
- use of suitable container
- initial temperature of acid
- add known mass of solid **C**
- final temperature/change in temperature
- repeat with solid **D**.

Two marks were awarded for correct conclusions answering the two questions.

CHEMISTRY

Paper 0620/63
Alternative to Practical

Key messages

- Candidates are advised to plan their answers to **Question 4** before starting to write. This would avoid the need to try and insert missing parts at a later stage. There is no need to write a list of apparatus at the start; if a mark is available for selecting suitable apparatus then it must be clear what that apparatus is being used for and so it must be mentioned in the method.
- Observations are those which you can see. For example, 'fizzing' is an observation, whereas 'a gas was given off' is not. Smells, such as the 'pungent smell of ammonia' or 'the bleach smell' 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 the mark will not be awarded.

General comments

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

The vast majority of candidates were able to complete tables of results from readings on diagrams in **Question 2**. Most went on to plot the points on a grid, draw a curve of best fit and taking a reading from their graph.

Question 4 was a planning task based on the separation of the three components of a cleaning product. The most common method was by filtration, followed by fractional distillation. Other methods could gain credit.

Comments on specific questions

Question 1

(a) Most candidates correctly labelled the dropping pipette and many also labelled the mortar correctly.

(b) The vast majority knew the test for carbon dioxide. Using a lighted splint is insufficient as any gas that does not support combustion would extinguish it.

(c) Most realised that the lumps were crushed to increase their surface area and, therefore, to increase the rate of the reaction.

(d) Most candidates incorrectly thought that copper could be obtained from a solution of copper nitrate by crystallisation. Better performing candidates correctly stated displacement or electrolysis. Other correct methods were credited.

Question 2

(a) Most candidates could read the stopwatches correctly.

(b) Most candidates could plot the points and draw a line of best fit correctly.

(c) Most candidates could take the temperature reading at 60 s; a few read the time at 60°C. Some candidates omitted the unit.

(d) **(i)** Most candidates identified Experiment 4 as the fastest.

(ii) These candidates went on to explain that this was because the particles had more kinetic energy and this resulted in a higher frequency of successful collisions.

(e) Candidates found this part more challenging. The most common correct answer was to use insulation or a lid (or even a water bath) to reduce heat loss, to prevent the temperature changing during the experiment. More correctly suggested repeating the experiment and taking an average or comparing the results. However, a few went on to explain that this would reduce the effect of random errors or enable anomalies to be identified and ignored. Other correct suggestions were credited.

(f) Candidates found this challenging. Better performing candidates stated that adding the reagent directly from a burette would take too long and therefore affect the timing of the experiment.

Question 3

(a) Some candidates realised that lithium nitrate is white, with red being the most common incorrect answer. Some candidates went on incorrectly to say that it was a solution or precipitate, thus losing the mark.

(b) Most candidates realised that the product would be ammonia and went on to mention bubbles and/or a pungent smell, as well as the correct test.

(c) The qualitative analysis tests were generally well known. Most realised that there would be no change or no precipitate with nitric acid and barium nitrate solution.

(d) Nearly all candidates knew that lithium's flame colour was red.

(e) Most candidates correctly identified the chloride ion; the idea of a transition metal cation and the salt being hydrated were less common. However, a number of responses identified manganese ions or cobalt ions.

Question 4

Most candidates removed the solid sodium carbonate by filtration and then went on to collect samples of ethanol and limonene by fractional distillation, with limonene either the second distillate or the residue. Others went straight into fractional distillation with sodium carbonate as the residue. A slight variation was to use fractional distillation to separate ethanol followed by filtration. All of these methods could gain full credit.

A small minority misunderstood the question and carried out tests on separate samples of the three components. An even smaller group used an inappropriate method of separation such as chromatography.