CHEMISTRY

Paper 0971/11
Multiple Choice (Core)

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

General comments

Candidates found **Questions 3**, **14**, **22** and **35** to have the least demand. Candidates found **Questions 10**, **25**, **33** and **37** the most demanding. All candidates found use of chemical properties to deduce the identity of a substance, such as **Questions 17**, **25** or **33**, difficult.

Comments on specific questions

Question 8

The distribution of options suggested guessing by some candidates.

Question 9

Many of the candidates chose option **C**. These candidates recognised the value should be multiplied by two but did not include the nitrogen atom in the calculation.

Question 10

All candidates found this a difficult question. The most common error was to think that a metal (sodium) would form at the cathode in the electrolysis of aqueous sodium chloride rather than hydrogen.

Question 11

Few candidates chose option **A**, but options **C** and **D** were common incorrect answers showing candidates were most likely to confuse the role of aluminium in overhead electricity cables.

Question 17

Candidates found this question difficult and there was evidence of guessing. The acidic nature of options **A** and **D** were mostly well recalled, suggesting that the displacement of ammonia from ammonium was not well remembered.

Question 25

All candidates found this question difficult. The most common answer was option **A**. Candidates found it difficult to recall the three key reactions of metals: with water, with dilute acid and the reaction of the oxide with carbon.

Question 27

Although most candidates answered this correctly, over a third of candidates chose option **D**, indicating some confusion between the terms conductor and insulator.

Question 30

Only a third of candidates gave the correct response. In this question, statement 2 was an incorrect statement present in three of the options. This suggests that NPK fertilisers were not well recalled.

Question 33

This question was the least well answered on the paper. Many candidates chose option **A**. It is important that candidates read through all the information given. In this question, the third statement should give a strong piece of evidence to lead to the correct answer.

Question 36

Candidates who performed less well were more likely to choose one of the distractors rather than the correct answer.

Question 37

Candidates did not recall the structure of poly(ethene) well. Option **C** was the most common answer. Candidates should check the bonding in organic compounds as many could not recall that carbon only makes four bonds.

Question 39

The most common incorrect answer was option **A**, where candidates thought that all petroleum fractions were used as fuels.

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Paper 0971/21
Multiple Choice (Extended)

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

General comments

Candidates found **Questions 3**, **14**, **17**, **22**, **28**, **30**, **31** and **40** to have the least demand. Candidates found **Questions 21** and **25** the most demanding. Questions requiring deductions based on chemical information were found to be most difficult; these include **Questions 15**, **26**, **29** and **34**.

Comments on specific questions

Question 1

This question tested both understanding of diffusion and indicators. Option **A** was commonly chosen, especially by the weaker candidates.

Question 5

Option **C** was chosen by many candidates.

Question 6

Candidates who performed less well were more likely to choose options **A** or **C**, suggesting some confusion about the structure of silicon(IV) oxide.

Questions 8, 10 and 12

These questions discriminated strongly between candidates. Those that performed less well were as likely to give any of the options.

Question 13

Some candidates were more likely to choose option **C**, which was a balanced equation for combustion of a fuel but not the equation for the fuel cell.

Question 15

A majority of candidates answered this question correctly, although a significant number chose option **D**. This suggests that many candidates were unclear about the role of activation energy in reaction rate.

Question 21

Only a third of candidates answered this question correctly. All the options were chosen although option **B** was most popular, suggesting that candidates confused ammonium and ammonia.

Question 22

This relatively straightforward question was well answered by most candidates; others chose option **C**.

Question 25

Most candidates recognised that sodium reacts with cold water but thought that copper reacted with dilute hydrochloric acid. Candidates are reminded that the least reactive metals form oxides which do react with carbon.

Question 29

Relatively few candidates chose options **A** or **D**. Almost a third chose option **C** suggesting some confusion between reaction rate and the position of equilibrium.

Question 34

Most candidates were able to eliminate option **D**. Candidates who performed less well tended to choose option **B**. Candidates are remined that they need to be able to give both the molecular and structural formula of the compounds listed.

Question 36

The distribution of answers from some candidates suggested some guessing.

Question 39

Option **C**, where both columns are incorrect, was the most common incorrect answer.

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Paper 0971/22
Multiple Choice (Extended)

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

General comments

Candidates found **Questions 2**, **12**, **14** and **32** to have the least demand. Candidates found **Questions 9** and **13** the most demanding.

Candidates must take particular care when answering questions which contain a negative statement, such as ‘not’ or ‘cannot’. These were found in **Questions 30** and **34**.

Comments on specific questions

Question 1

Option **A** was the most common incorrect answer. Candidates must take care to read the whole question. The indicator was to turn red, which required an acidic gas.

Question 7

Some candidates chose option **B**, incorrectly assuming that Group I and Group VII elements form covalent bonds.

Question 9

The question was one of the most demanding question on the paper. Options **A** and **B** were both popular answers.

Question 10

The question required candidates to recall the electrode product of two different electrolysis experiments. Some candidates chose one of the options, especially option **D**, which showed recall only of aqueous electrolysis.

Question 13

This was one of the more demanding questions on the paper. Candidates were required to recall how conditions change both reaction rate and the quantity of product produced. Option **A** was a common error.

Question 19

This question required candidates to use data on an unfamiliar compound to make a deduction about precipitation. All options were chosen equally, which suggested guessing.

Question 21

Fewer than half of the candidates were able to recall the role of the hydrogen ion in acidic solutions. Option **D** was the most common incorrect answer.

Question 23

Few candidates were distracted by option **A** or **C**. Option **B** was the most common incorrect answer, suggesting that the trend in density of Group **I** elements is not well known.

Question 30

Some candidates incorrectly chose option **C**.

Question 34

Some candidates were more likely to choose option **C**, which is a correct statement but does not answer the question.

Question 39

Candidates who performed less well were more likely to choose option **C**, where neither column of the table is correct.

CHEMISTRY

Paper 0971/31
Theory (Core)

Key messages

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

General comments

Many candidates tackled this paper well, showing a good knowledge of core Chemistry. Nearly all candidates were entered at the appropriate level. The standard of English was generally good. Some of the questions were left unanswered.

Some candidates need more practice in writing answers with the correct amount of detail and using or explaining specific chemical terms. For example, in **Question 2(f)(ii)** many candidates did not appear to know the difference between the separation and arrangement of particles. In **Question 2(f)(ii)**, many did not use the word 'diffusion' or refer to 'particles'. In **Question 4(b)**, attempts to explain the term 'unsaturated' were often hampered by vague statements. Many candidates need more practice in writing definitions. For example, in **Question 4(c)(i)** many candidates had difficulty in explaining the term 'polymer' and in **Question 5(c)(i)** many missed out the essential words 'compound' or 'only'. Others confused the terms 'elements' and 'compounds' at various points throughout the paper. In **Question 8(g)**, many candidates wrote about compounds of metals, rather than mixtures of metals, when asked to define the term 'alloy'.

Many candidates need more practice in analysing the stem of a question to pick out the essential words needed to answer the question. In **Question 2(a)(ii)**, many candidates did not use the information in the table as requested and hence gave the incorrect formulae for the ammonium and sulfate ions. In **Question 2(c)**, many did not heed the words 'other element' in the stem of the question and gave the names of compounds or potassium, which was in the stem of the question as an example. In **Question 3(b)(ii)**, many candidates gave medical uses of isotopes rather than industrial uses. In **Question 3(c)(ii)**, many candidates would be advised to specify exactly which substance is losing the oxygen and not just refer to elements which appear on both sides of the equation. Others just gave a definition of oxidation rather than referring to the equation. In **Question 7(a)(ii)**, some candidates referred to carbon or graphite, which had already been quoted in **(a)(i)** of this question. Candidates should be advised to look out for the word 'other' in a question so that they do not repeat what is in the stem.

Some candidates would benefit from further revision of specific topic areas such as organic chemistry (**Question 4**), atomic and electronic structure (**Questions 1(b)** and **7(b)**) and electrolysis (**Question 7(a)**).

Many candidates would benefit from learning specific practical procedures or observations. For example, in **Question 4(d)** many candidates did not write correct observations for the reaction of magnesium with acid. In **Question 5(b)(i)**, many candidates drew a series of closed or open containers or distillation apparatus instead of a gas syringe attached to a flask. Others did not label their apparatus or had large gaps for the gas to escape. In **Question 6(a)**, many candidates did not give precise information about how to measure the pH using universal indicator paper. Many gave colours relating to pH values rather than stating how to use the universal indicator solution by comparison with the colours on the indicator colour chart.

Some candidates need to revise qualitative tests for specific ions and molecules. The answers to the questions about the flame test for lithium ions (**Question 2(b)**), the test for calcium ions (**Question 5(a)(ii)**) and the test for water using anhydrous cobalt(II) chloride (**Question 5(d)(ii)**) were not well known.

Some candidates were able to extract information from tables and graphs, balance symbol equations and undertake simple chemical calculations. Others need more practice in these skills.

Comments on specific questions

Question 1

This was the best answered question on the paper. Many candidates identified at least three of the substances correctly in **(a)**. In **(b)**, most candidates were able to deduce the correct number of protons and neutrons. The better performing candidates deduced the correct number of electrons as well.

(a) (i) Most candidates realised that atoms of Group II elements have two electrons in their outer shell. The commonest errors were to suggest **B** (four electrons in the outer shell) or **E** (seven electrons in the outer shell).

(ii) Nearly all the candidates correctly identified **D** as having 13 protons. The commonest error was to miscount the electrons and suggest **C**, which has 12 electrons.

(iii) Some candidates recognised that a Group VII element forms an ion with a single negative charge. The commonest error was to ignore the phrase 'forms a stable ion' and to suggest **A**, which has a single electron in the outer shell of the atom.

(iv) A minority of the candidates realised that **B** was carbon and therefore forms a giant covalent structure. The commonest error was to suggest **A**, which has the greatest number of electrons.

(v) Some candidates knew that aluminium is used to make food containers and identified the electronic configuration of aluminium. A variety of incorrect answers were seen, the commonest being **C** (magnesium).

(b) Some candidates did not appear to recognise the isotopic notation. The commonest errors in deducing the number of protons were to confuse the mass number and proton number or suggest that the calcium ion has 18 protons, even when the number of electrons was incorrect. The number of neutrons was usually correctly deduced, the commonest errors being to give the mass number or to add the number of protons to the mass number. Most candidates ignored the charge on the calcium ion and gave the number of electrons in an atom of calcium.

Question 2

Some candidates gave good answers to **(a)(i)**, **(a)(iii)** and **(d)**. In **(a)(ii)**, many did not use the information in the table and wrote incorrect formulae. Few knew the correct flame colour in **(b)** and in **(c)** only the better performing candidates gave the name of two elements commonly found in fertilisers. In **(f)**, many candidates need further practice in interpreting the properties of gases in terms of the kinetic particle model.

(a) (i) Many candidates selected the chloride ion as having the highest concentration in the fruit juice. The commonest error was to suggest 'potassium' through not reading the question carefully enough, selecting the positive ion rather than the negative ion.

(ii) A minority of the candidates gave the correct formulae. Others did not refer to the information in the table and wrote the formulae for sulfide ions or, for example, SO_2^- for sulfate. Another common error was to write NH_3 or N for ammonium. Others wrote the correct symbols but without the charges or with incorrect charges.

(iii) Many candidates did the calculation correctly using simple proportion. Others tried to use moles e.g. $\frac{200}{23}$ = 8.7 or 23 × 2 = 46. Candidates should realise there is no requirement to complete mole calculations in the core part of the syllabus. Other common errors were 80 (by taking 120 away from 200) or 24 000 (by mistakenly thinking that the concentration was in g / dm^3).

(b) This was one of the least well answered parts of this question. Some candidates knew that a flame test was involved but most gave an incorrect flame colour, usually lilac or yellow. Others suggested adding water or doing electrolysis. A considerable number of candidates suggested using litmus or universal indicator paper, perhaps thinking of the alkaline solution formed when lithium reacts with water.

(c) A minority of the candidates realised that nitrogen and phosphorus were the other elements present in fertilisers. Some suggested potassium which was in the stem of the question. Others gave the names of compounds rather than elements e.g. phosphates. A majority of the candidates gave other elements such as calcium, sulfur or sodium. A considerable minority suggested water.

(d) This was the best answered part of this question. A small number of candidates suggested pH values other than 4; pH 7 being the commonest incorrect answer.

(e) Candidates found this challenging. A majority of the candidates gave the names of elements rather than compounds. Many of these elements were those found in fertilisers e.g. phosphorus, potassium. Calcium or sulfur were also commonly seen as incorrect answers. The commonest incorrect compounds seen were components of fertilisers e.g. nitrates.

(f) (i) The best answers referred to the arrangement of molecules being irregular and the separation being ‘far apart’. A majority of the candidates did not appear to know the meaning of the term ‘arrangement’ and wrote answers relating to motion or separation of the particles. The degree of separation of the particles in a gas was often not well explained, with many candidates suggesting that the particles were ‘separated’ (which cannot be given because the word is in the stem of the question). Others wrote vague statements such as ‘there is a lot of room’ or ‘they move from each other’. Many confused separation with motion.

(ii) A minority of the candidates gave good answers which referred to the random movement of particles by the process of diffusion. Many did not gain credit because they did not refer to particles or molecules but just stated that ‘the hydrochloric acid moves’, ‘the gas spreads out’ or ‘the gas reacts with the litmus’.

Question 3

Many candidates did not gain credit in **(a)(iii)** because they wrote answers which were too vague. In **(b)**, few candidates gave a full enough answer to **(i)** and many gave medical uses of radioactive isotopes in **(ii)** rather than industrial uses. In **(c)(ii)**, only the better performing candidates realised that they needed to refer to oxygen loss from iron oxide rather than give a generalised definition of reduction.

(a) (i) Many candidates deduced the boiling point and atomic radius correctly. The commonest errors were to suggest that the boiling point of rubidium is less than 671 °C or that the atomic radius of potassium is less than 0.191 nm. A few candidates gave negative values for the atomic radius or boiling point.

(ii) The majority of the candidates referred to the correct trend. Some tried to link the melting point to the atomic radius, boiling point or reactivity of the elements.

(iii) Many candidates deduced the correct physical state but few gave a convincing reason. Some candidates suggested that the physical state was between a liquid and a solid. Fewer suggested that potassium is a gas at 60 °C. The reasons given were often too vague e.g. ‘it’s not yet changed to liquid’ or ‘it’s not gone to its melting point’. The best answers referred to 60 °C being below the melting point. Some candidates suggested, incorrectly, ‘below the boiling point’.

(b) (i) Many candidates just paraphrased the stem of the question and gave the simple answer ‘the number of protons’ without adding any qualifying statements such as ‘in the nucleus of an atom’. Others wrote ‘the number of protons in an element’, which is not accurate enough because many elements have more than one atom in a molecule/giant structure.

(ii) The best answers referred to ‘measuring thickness of the paper’ or ‘checking for leakages in the pipes’. A majority of the candidates referred, incorrectly, to medical applications, X-rays or batteries. Others wrote vaguely about explosions or bombs, which are not industrial uses.

(c) (i) Many candidates were able to balance the equation. The commonest errors were to attempt to balance with 2NaOH, 6NaOH or to reverse the balance as 3Fe + 2 NaOH.

(ii) A minority of the candidates referred to oxygen being removed form the iron oxide. Some suggested that oxygen is being removed from iron, which is not accurate enough, since iron is on the right of the equation. Other just gave a definition of reduction as 'loss of oxygen' without referring to the equation as requested in the question. Candidates should be encouraged to read the question carefully to make sure they understand exactly what is being asked.

Question 4

Parts **(a)(ii)** and **(e)** were generally well answered. A minority of the candidates were able to identify the alcohol functional group correctly in **(a)(i)** or explain why compound **F** is described as unsaturated in **(b)**. In **(c)(i)**, some knew the meaning of the term 'monomer' but few could relate it to the formation of a polymer. A greater number of candidates could name the polymer of ethene but many gave the names of simple molecules. In **(d)**, many candidates knew the effect of an acid on litmus but very few described the correct observations when magnesium reacts with an acid.

(a) (i) A minority of candidates identified the alcohol functional group. The commonest errors were to circle the –COOH group or the –OH of this group or to include the CH next to the alcohol functional group. A considerable number of candidates included larger parts of the structure e.g. circling the top two carbon atoms and all the atoms attached.

(ii) Some candidates deduced the correct molecular formula. The commonest error was to include a functional group e.g. $C_3H_5O_3COOH$. Others did not count the number of each type of atom correctly, the commonest errors being to have fewer carbon or hydrogen atoms.

(b) The best answers referred to double bonds between the carbon atoms. Most candidates wrote answers which, although carbon atoms were mentioned, were too vague e.g. 'there is a carbon with a double bond' or 'there are double bonds' (without mentioning carbon-carbon). Others wrote even vaguer or incorrect statements such as 'the structure is not complete' or 'the compound is an alkene'.

(c) (i) Some candidates recognised that a polymer is made from monomers or small units. Others wrote statements about 'atoms combining' or 'polymers joining'. Few candidates wrote about polymers being long chain molecules or macromolecules. Some suggested 'giant structures' but this is too generalised. A considerable number of candidates did not respond to this question.

(ii) A minority of the candidates named poly(ethene) correctly. Most gave either examples of other polymers such as 'nylon' or monomers such as esters or ethene. A considerable minority gave the names of alkanes such as 'methane' or 'ethane'. A considerable number of candidates did not respond to this question.

(d) Some candidates knew that blue litmus turns red on addition of acid. Others suggested that litmus turns blue or brown. Very few candidates described the observations when magnesium reacts with ethanoic acid. Many focused on the products such as 'hydrogen is formed' (or more often the incorrect 'carbon dioxide is formed'). A considerable number of candidates gave colour changes of the solution or colour changes after litmus was added to the solution formed by reaction of magnesium with acid. Others suggested 'white precipitate'. A considerable number of candidates did not respond to this question.

(e) (i) Many candidates read the correct pH value from the graph. The commonest error was to suggest pH 4.2; the pH value when there is excess acid.

(ii) Many candidates deduced the volume correctly. A common error was to suggest 40 cm^3 (the volume at the far right of the graph), rather than focussing on the pH value at pH 7. Another common error was to suggest 11.6 cm^3, through not interpreting the values on the horizontal axis of the graph correctly.

Question 5

Some candidates were able to define the term 'thermal decomposition' in **(a)**, describe the effect of change of concentration and temperature on rate of reaction in **(b)(ii)** and name the homologous series in **(c)(ii)** well. Very few candidates knew the test for calcium ions in **(a)(ii)** or drew a suitable diagram in **(b)(i)**. The meaning of the term 'hydrocarbon' was not well known in **(c)(i)** and in **(c)(iii)** a minority of the candidates were able to name two substances formed by the incomplete combustion of propane.

(a) (i) Many candidates realised that the word 'thermal' related to heating. Fewer described the word 'decomposition' as 'breaking down'. Many candidates simply repeated the word decomposition. Candidates should be advised that if there are two distinct words in a definition, both need to be defined. Some did not gain credit for heating because the word was used out of context e.g. 'heat is given out during the reaction'.

(ii) The minority of candidates who knew a test for calcium ions either gave the correct flame test or knew the results of the test using sodium hydroxide or ammonia. Those candidates who suggested a flame test general got the correct colour flame: brick-red. Those who opted for addition of aqueous sodium hydroxide often did not gain credit because they went on to suggest that the white precipitate is soluble in excess. A large number of candidates chose the wrong test reagent; silver nitrate being commonly seen. A considerable number of candidates did not respond to this question.

(b) (i) The best answers showed an accurate labelled drawing of a gas syringe with graduations and connected to a closed vessel. Some candidates drew apparatus that did not have anything resembling a plunger and was not labelled. Many candidates drew a measuring cylinder connected directly to the reaction flask. A significant minority did not draw a reaction vessel. Many candidates drew unworkable apparatus, including apparatus which allowed gas to escape into the air. A considerable number of candidates did not respond to this question.

(ii) Most candidates obtained partial credit for a description of the effect of change of concentration and temperature on rate of reaction. A minority referred to time taken rather than rate of reaction, whilst other candidates wrote answers in terms of the kinetic particle theory and did not mention rate of reaction.

(c) (i) Some candidates gave an accurate description of the term 'hydrocarbon' including the words 'compound' and 'only'. The commonest errors were to write about mixtures or molecules of hydrogen and carbon or to omit the essential word 'only' to imply that there are no other elements present. A considerable number of candidates suggested that hydrocarbons contain oxygen.

(ii) Many candidates were able to name the homologous series to which propane belongs. The commonest errors in terms of homologous series were to suggest either alkenes or alcohols. Others named specific compounds; 'hydrogen' or 'methane' were common incorrect answers. A considerable number of candidates did not respond to this question.

(iii) A minority of the candidates gave two correct products of incomplete combustion. Many candidates gained credit for either 'water' or 'carbon monoxide' but fewer chose 'carbon'. Many candidates suggested, incorrectly, that hydrogen is formed. Other suggested specific hydrocarbons.

Question 6

Most candidates identified at least one of the correct gases in the air in **(b)(i)** and gave the correct reason for the use of chlorine in water treatment in **(b)(iii)**. In **(a)**, few candidates were able to explain exactly how universal indicator paper can be used to determine pH. In **(b)(ii)**, better performing candidates were able to describe the idea of trapping larger particles while the smaller water molecules passed through the filter. The test for water using anhydrous cobalt(II) chloride in **(c)** was not well known; many candidates confused it with the test for water using anhydrous copper(II) sulfate.

(a) Some candidates referred to dipping the indicator paper into the water. The majority of the candidates just referred to 'using the universal indicator to find the pH'. The best answers included the idea of matching the colour of the indicator paper to the colours on a universal indicator colour chart. A majority of the candidates just stated various colours that might be seen at different pH values e.g. 'if it's pH 4 the colour is red'. Others did not seem to know about universal indicator and just wrote about litmus changing from red to blue or blue to red.

(b) (i) A majority of the candidates were able to name at least one of the two main gases in the air. The commonest errors were to suggest either 'carbon dioxide' or 'hydrogen'.

(ii) Better performing candidates were able to describe the idea of trapping larger particles between the particles of sand while the smaller water molecules passed through the filter. Many candidates did not gain credit because they wrote about filter papers and the sand being trapped on the filter paper. A considerable minority thought that the question was about separating sand and stones or sand and insoluble particles. Others suggested, incorrectly, that the separation occurs because the insoluble particles 'stick to the sand'.

(iii) A majority of the candidates knew that chlorine kills bacteria/microbes. The commonest incorrect answers referred to 'acidifying the water' or the vague 'cleaning water'. Other vague answers were 'to kill pollutants' or 'to kill particles'.

(c) The test for water using anhydrous cobalt(II) chloride was not well known and many candidates confused it with the test for water using anhydrous copper(II) sulfate. Some candidates knew the colours 'blue' or 'red' in the appropriate place but few candidates knew both colours. Other common incorrect colours were 'orange' or 'colourless'.

Question 7

This was the least well-done question on the paper. Many candidates gave incorrect products at the electrodes in **(a)(i)**, sometimes giving elements or ions unrelated to lead or bromine. In **(a)(ii)**, a wide variety of elements other than platinum were given. In **(b)**, many candidates forgot that the first electron shell only contains a maximum of two electrons and added extra non-bonding electrons to one or both hydrogen atoms.

(a) (i) A minority of the candidates deduced that lead is formed at the negative electrode and bromine at the positive electrode. Many candidates wrote lead(II), which implies a lead compound, or lead ions instead of lead and bromide instead of bromine. Many candidates did not heed the statement about the lead bromide being molten and suggested oxygen or hydrogen forming at either electrode. A minority of the candidates wrote answers related to the electrodes rather than the electrode products e.g. 'cathode' and 'anode'; others gave observations.

(ii) A minority of the candidates suggested platinum. The commonest error was to suggest 'graphite' or 'carbon' despite the fact that the question asked for another substance (other than carbon). Many candidates suggested highly improbable electrode material such as 'carbon dioxide' or 'water'.

(b) Many candidates forgot that the first electron shell only contains a maximum of two electrons and added extra non-bonding electrons to one or both hydrogen atoms. Others gave the electronic configuration for hydrochloric acid instead of hydrogen and included the symbols H and C*l*. A few candidates did not show the bonding pair of electrons and showed the two electrons as a non-bonding pair or as one non-bonded electron on each hydrogen atom.

Question 8

This was one of the better answered questions on the paper. Many candidates identified the properties of an element with simple covalent bonding in **(a)** and deduced the order of reactivity in **(e)**. Most candidates were able to write the symbol for a reversible reaction in **(f)**. In **(b)**, many candidates did not refer to metals whilst in **(c)** and **(d)** a minority of candidates gave convincing answers about the lack of reactivity of krypton and the difference between transition element and Group I metals. In **(g)**, many candidates did not gain credit because of either conflicting statements or vague answers.

(a) Those candidates who knew the properties of simple covalent molecules usually gained full credit. A significant proportion of candidates suggested **P** and **R** rather than **Q** and **S** but some of these seemed to guess the properties and gave one correct answer related to simple covalent compounds.

(b) Many candidates suggested that element **T** forms a basic oxide. Few related this to metallic character. Common incorrect answers included 'because its acidic' or 'because its reactive'.

(c) The best answers referred to a full outer shell of electrons. Common incorrect answers ranged from the vague 'because it's a noble gas' to incorrect statements such as 'it's got no free electrons'.

(d) Many candidates gave one correct difference between transition elements and Group **I** elements. Few gave two differences. Many confused the differences, suggesting that sodium 'has a high melting point' or 'sodium is denser'. Some candidates chose malleability or ductility but did not gain credit because they suggested that transition elements were not malleable or ductile rather than less malleable or less ductile. A significant number of candidates referred, incorrectly, to rusting or magnetism, properties which only apply to iron (for rusting) or iron, nickel and cobalt for ferromagnetic properties.

(e) Most candidates deduced the correct order of reactivity. The commonest errors were to suggest that nickel is less reactive than copper or to reverse the order completely.

(f) Nearly all the candidates were able to draw the correct symbol for a reversible reaction. The commonest error was to draw a single double-headed arrow. A few candidates drew a circle with an arrowhead.

(g) The best answers focused on a mixture of a metal with another element. Many did not gain credit because they did not write the essential word 'mixture' or contradicted themselves by including the word 'compound'. A significant minority did not mention that one of the components has to be a metal.

CHEMISTRY

Paper 0971/41
Theory (Extended)

Key messages

- When any question asks, 'State what happens to the position of equilibrium?', the only possible acceptable answers are:
  - shifts to the right
  - shifts to the left
  - no change.

  Any other references, e.g. 'to more product formed / equilibrium shifts in the endothermic direction' are ignored during marking.
- When a question asks for a molecule to be drawn showing all the atoms and all the bonds, it is not acceptable to leave out the O-H bond.
- When a question asks for the name of a substance, candidates should ensure that their answer is a name as opposed to a formula or an equation.
- Some candidates alter responses instead of rewriting them, this often makes their answer difficult or impossible to read.

Comments on specific questions

Question 1

(a) The Haber process was known by many candidates. A wide variety of spellings was seen. Nitrification and the Contact process were seen occasionally.

(b) This was answered quite well. Distillation was occasionally seen instead of fractional distillation.

(c) This was answered quite well. There were no common incorrect answers.

(d) This was answered very well. There were no common incorrect answers.

(e) Candidates found this the most difficult part of **Question 1**. Condensation polymerisation was a very popular answer. A wide variety of other answers was seen including deamination, depolymerisation, fermentation, cracking, decomposition and hydration.

(f) This was answered quite well. Distillation and fractional distillation were occasionally seen.

Question 2

Candidates usually performed well on this question. The nucleon number of chlorine was occasionally seen as either 35 or 35.5 instead of 37. For the copper ion, the number of electrons was often given as 31 rather than 27. The missing symbol was occasionally identified as Rb (proton number 37).Candidates should be aware that if a symbol for an element has two letters, as in the case of Cl ,the second letter must be clearly seen to be lower case. This also applies in **Question 3(a)**.

Question 3

(a) The formula of chlorine was often represented as either Cl or Cl^-. Some candidates gave the wrong formula for potassium chloride, even though KCl was given in the question.

(b) The potassium ion was often given the electron arrangement of 2,8. Those who drew the chloride ion as 2,8,8 often used 8 dots in the outer shell. It is good practice to draw electrons in pairs.

(c) (i) Candidates should make sure that they are adequately prepared for questions of the type 'State what is meant by the term...'. Candidates should be aware that the substance that is decomposed must be molten or aqueous.

(ii) Candidates should be aware that molten potassium chloride only contains the elements potassium and chlorine. Thus potassium and chlorine are the only possible products of electrolysis of molten potassium chloride. Some candidates gave equations despite being asked for names of the products. The products at the anode and cathode were occasionally reversed. Common incorrect answers included potassium ions, chloride ions, chloride (as opposed to chlorine), K^+, Cl and Cl^-.

(d) (i) Candidates performed poorly on this question. Many gave equations for the discharge of potassium ions or chloride ions.

(ii) Chloride, chloride ions, Cl or Cl^- were often seen as incorrect answers. Hydrogen was occasionally seen.

(iii) Potassium oxide and potassium chloride were seen quite often. Some candidates gave answers other than potassium compounds.

(e) This was answered very well. Multiple bonds were drawn very occasionally. It is good practice to draw electrons in pairs.

(f) (i) Many gave the correct physical state as liquid. It was unusual to see candidates referring to all three temperatures in their explanations. Many seemed to have difficulties in dealing with negative numbers. Some candidates referred to room temperature which was an irrelevancy. Candidates often referred to either melting point or boiling point instead of referring to both melting point and boiling point.

(ii) Many answers referred only to potassium chloride without any reference to chlorine. Ionic bonds between atoms or molecules or intermolecular ionic bonds were seen regularly. Weak covalent bonds in chlorine were referred to regularly and incorrectly. A statement that said the bonding in potassium chloride is weaker than the bonding in chlorine was often missing.

Question 4

(a) Candidates should make sure that they are adequately prepared for questions of the type, 'State what is meant by the term...'. The forward reaction is equal to the reverse reaction (without reference to rate) was seen often. The 'concentrations of reactants and products become equal' was another common answer.

(b) (i) Candidates found this was the most demanding question on the paper. Successful answers had to refer to nitrogen dioxide without saying more nitrogen dioxide was formed or suggesting that the equilibrium shifted. Nitrogen dioxide molecules being pushed closer together or an increase in the concentration of nitrogen dioxide due to the increased pressure were mentioned only rarely.

(ii) The equilibrium shifts to the left because there are less molecules on the left-hand side of the equation than on the right-hand side. Those that mentioned that the pressure increased had to go on to state the significance of this. Vague statements such as ‘to restore the balance / to obey Le Chatelier’s principle / to oppose the change in pressure / the backwards reaction has less molecules’ were all common.

(c) (i) Responses that attempted to answer the question without referring to the position of equilibrium were extremely common.

(ii) There was a great deal of confusion between equilibrium and rates of reaction. The rates of **all** chemical reactions (with the exception of reactions that are catalysed by enzymes) increase as the temperature increases. Thus the rates of both forward and backward reactions increase in this case. Candidates were usually reluctant to give the same answer to both parts of the question.

Question 5

(a) Many candidates mixed the two solids together without dissolving them in water first. Descriptions of separation or filtering the sodium ions from the iodide ions and the lead ions from nitrate ions and then mixing the iodide and lead ions together or other similar statements were seen. Washing the residue after filtration was often mentioned without reference to water being used for the washing.

Equations were often unbalanced or contained incorrect formulae such as PbI (despite PbI_2 being given in the stem).The formula of sodium nitrate was often written with unnecessary brackets as $Na(NO_3)$. Equations should be written on one line.

Unnecessary work on the filtrate, including descriptions of crystallisation, was occasionally described.

(b) (i) Candidates found this challenging. Burning splints relighting was a common answer.

(ii) Candidates performed very badly on this question. Candidates seemed unaware that the **2** at the beginning of **2**$Zn(NO_3)_2.6H_2O$ multiplies everything in the formula that follows it. The **2**ZnO was commonly seen. **4**NO_2 was less common. Unfortunately, **6**H_2O was very common. **12**H_2O was only seen extremely rarely.

(c) (i) Candidates were largely unaware of the practical technique required to ensure that all the water had been removed. The hydrated salt should be:

- weighed
- heated
- cooled
- reweighed.

These steps should be repeated until there is no loss in mass i.e. the mass becomes constant. This indicates that all the water of crystallisation has been given off.

Qualitative techniques, such as those involving copper(II) sulfate or cobalt(II) chloride, do not detect very small quantities of water which may still be present in the crystals. Similarly, no apparent change in the appearance of the crystals is not a guarantee that a small amount of water is no longer present.

(ii) Many candidates calculated the first three values correctly but were unable to determine the value of ***x*** from the moles of H_2O and the moles of Na_2SO_4.

Question 6

(a) (i) This was answered quite well. Bauxite and iron oxide were seen occasionally.

(ii) Oxygen was commonly seen instead of, or as well as, air. It is unnecessary to use oxygen, which is much more expensive.

(iii) Slag was often spelt incorrectly and led to a loss of meaning e.g. ‘slug’. Carbon dioxide was a common incorrect answer.

(iv) Some candidates seemed to confuse this with the use of cryolite in the extraction of aluminium and stated, 'lowering the operating temperature' as the answer. 'Removing impurities' and 'catalyst' were seen very often.

(b) The symbol for sulfur had to be included in the answer. Some candidates gave numbers without a symbol as their answer. Others gave answers without a charge. Iron with a negative charge was seen occasionally. S^{2-} and $2S^{-}$ were both fairly common answers.

(c) (i) This was answered very well. There were no common errors. An extremely small number gave answers that were not on the list.

(ii) This was answered very well. There were no common errors. An extremely small number gave answers that were not on the list.

(d) (i) The majority of candidates wrote that magnesium is more reactive than iron. Further explanation often included the phrase 'sacrificial protection' without explaining its meaning. Magnesium rusting instead of iron was another incorrect answer. 'Magnesium forms a coating that acts as a barrier', was another false statement that was seen often.

(ii) 'Copper is less reactive than magnesium', is an irrelevant statement that was regularly seen. 'Copper is unreactive', without a comparison to iron, was also common.

Question 7

(a) There were some excellent answers to this question in which all steps of the working were clearly shown. Common errors included:

- dividing all three percentages by the lowest one, i.e. 8.11
- approximating the number of moles of carbon atoms from 1.5 to either 1 or 2
- attempting to multiply 1.5, 3 and 1 by two and achieving incorrect values
- dividing the percentages by the relative atomic masses and achieving the correct values of 4.05, 8.11 and 2.70. These were then approximated to 4, 8 and 3 (or 2), which gave rise to an incorrect empirical formula.

(b) Many gave numerical answers instead of chemical formulae. Some formulae had extremely large numbers of atoms. These molecules had relative molecular masses much larger than 32.

(c) (i) This was answered reasonably well. $C_nH_{2n}O$ / $C_nH_{2n}O_n$ / C_nH_{2n} + O_2 were common incorrect answers.

(ii) The O-H bond was often missing. Many molecules were drawn in which carbon, hydrogen and oxygen had numbers of bonds, which were different to the required numbers of 4, 1 and 2 respectively. Aldehyde groups(CHO) were occasionally drawn. Propanoic acid was occasionally seen instead of butanoic acid.

(iii) The spelling of homologous was sometimes incorrect. Carboxylic acid was occasionally seen, as were isomers and isotopes.

(d) (i) This was answered reasonably well. The correct colours were very occasionally written the wrong way round.

(ii) Many candidates chose to omit propene from their answer. Others ignored the requirement for a 1:2 molar ratio of products.

(iii) 'Additional' was often seen instead of addition. Condensation was occasionally seen.

(iv) Butane was commonly drawn. Poly(ethene) was the polymer that was drawn most commonly. Some products contained oxygen atoms. Very few answers contained CH_3 groups. Hydrogen atoms were often seen at both ends resulting in the formation of a small molecule as opposed to a polymer. A bracket was occasionally drawn around three carbon atoms as an attempt to represent propene.

CHEMISTRY

Paper 0971/42
Theory (Extended)

Key messages

- If a symbol or formula of a chemical is asked for, a name will not gain credit. This was the case in **Question 2(b)** where the formula of the acid was asked for. Candidates who wrote 'nitric acid' received no credit as they were not addressing the question.
- If the name of an organic compound is asked for, credit will only be given for a correct name as this shows understanding of the prefix and of the suffix of organic nomenclature
- Where candidates are required to select an answer from a set of possible choices, such as **Question 1**, then candidates should be encouraged to make sensible guesses rather than leaving an answer blank. There is no penalty for an incorrect attempt.

General comments

All marks were accessible to candidates and there appeared to be sufficient time for all questions to be answered.

The calculation questions were generally well done but many candidates found **Question 4**, involving electrolysis, and **Question 6**, involving organic chemistry, challenging.

Candidates must be prepared to do calculations using the mole concept.

Comments on specific questions

Question 1

Candidates performed well on this question, requiring choices from the eight Period 3 elements given in the question. Parts **(a)**, **(b)** and **(c)** were almost universally correct.

Parts **(h)**, **(i)** and **(j)** proved to be the hardest with less than two-thirds of the candidates getting these questions correct.

A common incorrect answer to **(j)** was **S**, which suggested that weaker candidates may have been unfamiliar with the term 'binary compound'.

Question 2

(a) (i) Most candidates knew that 'isotopes' was the name given to atoms of an element with different nucleon numbers, although 'isomers' was occasionally seen.

(ii) The numbers of sub-atomic particles were well known. Common errors were to either give each isotope the same number of neutrons or to give the Ag^+ ion one more electron than the Ag atom.

(iii) This question, asking for the definition of relative atomic mass, was written in an unusual manner. Instead of generating their own wording candidates had to fill in blanks. Candidates did not perform well with only a relatively small proportion gaining full credit.

Most candidates knew that relative atomic mass is an ‘average’ mass of naturally occurring atoms. The least well-known answer was that the scale is based upon a ‘carbon-12’ atom with just ‘carbon’ being the most frequent incorrect answer. Slightly more knew that the mass of this atom was ‘12.0’ units. Wild guesses included ‘6×10^{23}’ and ‘1 mole’

(iv) The understanding of the definition that relative atomic mass is the average mass of isotopes, was tested in this question. Candidates were expected to realise that if there were two isotopes, one weighing 107 and the other weighing 109, then if the relative atomic mass was 108.0, each isotope was present as 50 per cent of the atoms. A common error was to express $\frac{107}{108}$ as a percentage.

(b) Candidates need to be reminded that if a formula is asked for, the response ‘nitric acid’ will gain no credit. Candidates generally knew the answer, although H_2NO_3 was a common error. Some candidates attempted to write equations to show silver oxide reacting with nitric acid.

(c) (i) Relatively few candidates wrote ‘yellow precipitate’. The commonest error was to describe it as a white precipitate.

(ii) A large number of candidates wrote full equations or left spectator ions in their answer.

(d) Most candidates knew ammonia was the name of the gas produced from a nitrate within an alkaline solution, but a far lower proportion knew that aluminium was needed in order to generate ammonia.

(e) The term ‘photochemical’ was well known by better performing candidates. A frequent error was to use the term ‘photosynthesis’.

(f) (i) Many candidates misinterpreted what was required and wrote the name of a homologous series rather than the name of a member of the homologous series.

(ii) The question was designed to test if candidates knew the names of the products of a substitution reaction. The expected answer of ‘chloro’ used as a prefix to the named alkane was frequently seen.

Many candidates assumed HCl was ‘hydrochloric acid’, rather than the correct term ‘hydrogen chloride’. Candidates need to be told that HCl when generated in organic reactions is hydrogen chloride and, due to the absence of water, is not hydrochloric acid.

Question 3

(a) It was expected that the full term, ‘thermal decomposition’, would be used to describe the action of heat on sodium hydrogencarbonate.

(b) Although many of the better performing candidates successfully gained full credit, candidates struggled with the mole concept. Many candidates did not read the question correctly. The first part of the question wanted the mass of one mole of sodium hydrogencarbonate, whereas many divided the mass of sodium hydrogencarbonate, (12.6 g) by its molar mass (84 g) to give an incorrect answer of 0.15.

(c) Most candidates knew the formula for calcium hydroxide, slightly fewer scored the second mark, with many thinking the precipitate was CaO.

Question 4

(a) The term electrolyte was known by most candidates. Some candidates misinterpreted the question and gave a familiar example of an electrolyte.

(b) (i) Candidates were asked to complete an ionic half-equation, which was partially written. It was expected that candidates would firstly balance charges by inserting '4' before OH^- and would balance atoms by using $2H_2O$ as the missing product. Many candidates were unable to balance the atoms.

(ii) Most candidates picked up that the presence of four electrons on the product side meant OH^- ions had lost electrons.

(c) Most candidates correctly suggested effervescence would be seen. No credit was awarded for 'gas given off' or 'gas formed' as this is a conclusion made by observing the effervescence which takes place.

(d) The ionic half-equation for the cathode reaction was known by many. Candidates need to be aware that although $2H^+ + 2e^- \rightarrow H_2$ may be considered mathematically equivalent to $2H^+ \rightarrow H_2 - 2e^-$, the latter is not a correct chemical description of the changes taking place.

(e) (i) Most candidates knew that concentrated aqueous sodium chloride produced the same cathodic product as dilute aqueous sodium chloride and wrote effervescence or fizzing. Weaker responses suggested that sodium would be formed within this aqueous system.

Candidates had been told earlier in the question that oxygen is produced at the anode during electrolysis of dilute aqueous sodium chloride so 'effervescence' was not accepted as a suitable answer. Better performing candidates were able to state that a green gas was seen.

(ii) Most candidates correctly stated a blue colour for the litmus, correctly explaining that an alkaline solution of sodium hydroxide was left.

(f) This question proved to be difficult. Graphite was a common incorrect response and some opted for a metal far lower than hydrogen in the reactivity series such as silver, gold or platinum.

Question 5

(a) (i) The key to this equation was to realise that nitrogen was diatomic. Hence the balancing followed on from this. Candidates who performed less well tended to make a variety of errors, which showed a misunderstanding of equations.

(ii) The electronic structure of the nitride ion was well attempted. Only a small number omitted the extra three electrons needed to make up an octet.

The octet should be made up of five crosses (nitrogen electrons) and three dots representing electrons from lithium.

(b) (i) In general, candidates were confident in performing the two calculations involving bond energies and the answers 1425 kJ and 1800 kJ were frequently seen. However, a significant minority did not realise that the net energy change was found by subtracting 1800 from 1425 to give –375 kJ / mol. Doing the reverse subtraction to give +375 kJ / mol was a common error.

(ii) The current syllabus does not require candidates to know that a negative sign equates to an exothermic change, but many did know this. Candidates were expected to realise that the reaction was exothermic because the energy needed to break bonds was less than the energy released when bonds are formed.

Many candidates used incorrect phraseology, which suggested that bond formation required energy. A typical example of this would be, 'energy used to break bonds is less than the energy to used to make bonds' implying, incorrectly, energy was taken in to make bonds.

(iii) Many perfect answers were seen. The most frequent error was the omission of the non-bonding electrons on the fluorine atoms.

Most candidates pair non-bonding electrons. This is good practice as it is easier to check that atoms have a full outer shell. Candidates who opted to draw individual electrons often did not allocate the full eight electrons to fluorine atoms.

(c) The three key marking points were:

- lithium fluoride has attraction between **ions**
- lithium nitride has attraction between **molecules**
- the attraction between ions is stronger than attraction between molecules.

Many candidates stated LiF has attraction between ions and Li_3N has attraction between molecules and the intermolecular forces in LiF are weaker than the intermolecular forces in Li_3N thus stating LiF is molecular, which contradicted their earlier statement.

(d) (i) This calculation was completed correctly by most of the candidates. Where candidates did not derive 35 per cent as an answer the working was looked at. Many candidates left the relative formula mass calculation of ammonium nitrate (NH_4NO_3) as $14 + 4 \times 1 + 14 + 16 \times 3$ without providing a value for the relative formula mass.

(ii) Most candidates correctly stated ammonium nitrate is a fertiliser when used in agriculture. Vague responses such as 'to help plants grow' were not credited, neither were statements about changing the acidity of soils.

(iii) Better performing candidates demonstrated their knowledge of the syllabus. Others resorted to guesses, frequently suggesting mineral acids would displace ammonia from an ammonium salt.

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

(ii) Most candidates were aware that ammonia was a weak alkali and gave a suitable pH value within the accepted range of above pH 7 up to pH 11.

Candidates who wrote 'above pH 7' were not given credit as, for example, pH 14, which although above pH 7, would not be a weak alkali.

Question 6

(a) (i) Most candidates correctly named the functional group as carboxylic acid (carboxyl was also accepted) although a significant number gave –COOH as the answer, thus not gaining credit.

(ii) This was a challenging question about polymerisation. Candidates were asked to draw part of the polymer structure formed from two molecules of **A** and two molecules of **B**. They were asked to draw all the atoms and bonds in the linkages. Thus three 'inter-block' ester links were needed and the orientation of each ester link needed to match the shading of the 'blocks'. Being part of a polymer, continuation bonds were expected. Common errors were to omit the fully displayed structures of the linkages; incorrect orientation of the linkages; omission of continuation bonds.

Candidates need to consider the valencies of the atoms drawn; trivalent oxygen and carbon atoms were commonly seen in the linkages drawn.

(iii) Most candidates knew water was the other product in this condensation polymerisation.

(b) (i) The structure of the linkage in complex carbohydrates was poorly attempted.

(ii) The two sets of conditions were generally not known. The term 'enzyme' was seen more often than acid amongst those who did gain credit.

(iii) The use of chromatography in identifying individual sugars was not well known.

(c) (i) Most candidates knew that fermentation was the process which produced ethanol from glucose.

(ii) The equation for fermentation was less well known. Many candidates gave the products as $CO_2 + H_2O$, suggesting a possible confusion with respiration. A significant proportion of candidates gave C_2H_5OH as a product (C_2H_6O was also accepted) but incorrectly 'balanced' the equation by giving $C_4H_6O_5$ as the other product.

CHEMISTRY

Paper 0971/51
Practical Test 51

Key messages

- 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. The paper discriminated successfully between candidates of different abilities but was accessible to all. Almost all centres were able to gain the expected results in **Question 1** and **Question 2**.
- Candidates found the last question, **Question 3**, demanding.
- All centres submitted Supervisor's results as required.

General comments

The planning question (**Question 3**) needs to be carefully read so that time is not wasted with irrelevant planning to prepare materials which are provided.

Plotted points on a grid should be clearly visible e.g. crosses. Straight line graphs should be drawn with a ruler and labelled as required.

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

Lists of answers with correct and incorrect responses are marked according to a list principle and 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 credit can be awarded.

Comments on specific questions

Question 1

(a) The table of results was often completed correctly. A common error was not giving the temperatures and temperature changes to a consistent number of decimal places.

(b) Most plotted the points correctly but often not clearly. A common error was to plot the point for 5 g at 4 g. Some excellent graphs were seen. Most candidates chose a sensible scale for the *y*-axis of each 2 cm square being either 1 °C or 2 °C and were then able to plot the six points correctly. Some candidates did not follow the instruction regarding the lines having to be straight and for the right-hand line to be horizontal.

(c) (i) A significant number of candidates did not show clearly on the grid how they worked out their answer and/or missed out the units.

(ii) Better performing candidates realised that the acid had become the limiting factor and that excess sodium hydrogencarbonate was present. Vague answers such as 'the reaction finished/stopped' were common and received no credit.

(d) Candidates found this a demanding question. If the acid used had half of the original concentration, then all the acid would have been reacted with just half of the mass of sodium hydrogencarbonate as compared to the original investigation. If half the mass of sodium hydrogencarbonate reacts then the temperature decrease would be half the original decrease. Very few correct answers were seen. Some candidates realised that the mass of sodium hydrogencarbonate required would be half the original mass.

(e) Many candidates stated that a burette or pipette would be more accurate than a measuring cylinder. Fewer candidates realised that insulation would reduce heat gain from the surroundings. A common error was to suggest stirring with something other than a thermometer or to suggest repeating the experiment and finding a mean. The latter was not acceptable as the question specifically asked for a change to the apparatus.

Question 2

Solid **E** was aluminium ammonium sulfate. Solution **F** was aqueous sodium hydroxide.

(a) Some detailed observations were seen. The formation of condensation and the solid becoming liquid/melting were the two acceptable observations that were most commonly seen. References to bubbles and fizzing were ignored.

(b) The expected observation was 'white precipitate formed'. The term precipitate was required and statements such as cloudy were not sufficient. Some answers referred to no reaction.

(c) The expected observation was 'white precipitate formed'.

(d) Formation of a white precipitate was often described but only the best responses recorded that the precipitate was soluble in excess sodium hydroxide. Some candidates reported impossible colours such as blue or purple, which could only be the result of using the wrong reactants or contaminated test-tubes.

(e) Most candidates correctly reported a positive test for ammonia with litmus paper turning blue.

(f) Some candidates had difficulty in identifying three ions. A common error was to identify the ammonia given off in **(e)** rather than naming the ammonium ion from which it was formed. Some responses confused ammonia with the nitrate ion.

(g) Many correct flame test colours were seen, although it was evident from some candidate's answers, e.g. lighted splint pops, that they were not clear what a flame test was.

(h)(i) While most candidates gave an acceptable colour for the mixing of universal indicator with an alkali, some seemed not to have used universal indicator as they widely reported other unacceptable colours.

(ii) The expected observation was 'blue precipitate formed'.

(iii) The identity of solution **F** as a copper compound was common despite the fact that copper(II) sulfate had been added to solution **F** in **(h)(ii)**.

Question 3

A number of candidates unnecessarily spent time explaining, often in detail, how to collect the volume of gas produced using a gas syringe despite the information given in the stem of the question.

The candidates were told they had to use the information shown in the diagram. This meant that the plans had to be based on the mass lost during the reaction.

The most common methods used were to measure the mass lost in a specified time or to measure the time taken until the mass of the flask and contents stopped changing.

Some candidates opted to measure the mass lost when the mass stopped changing without measuring the time. This last method could not gain full credit as the final mass lost will be the same whatever the rate of reaction, as was the case for using methods that were not based on the loss in mass.

In order to produce valid results, each run at a different temperature should have the same mass of calcium carbonate and the same volume of acid.

It should be noted that ‘amount’ is not an acceptable term for mass or volume. As the independent variable is the temperature of the acid, experiments must be conducted using acid at different temperatures. However, the acid should not be heated so that its temperature is changing while it is reacting.

In all methods, timing is necessary and so an instruction as to when a timer is started was expected. Once a final measurement has been made, (be that mass lost in a set time or the time taken to stop reacting or lose a set mass), then there should have been an explanation of how the differences in that measured quantity relate to the rate of the reaction.

A minority of candidates did not attempt the question.

CHEMISTRY

Paper 0971/61
Alternative to Practical 61

Key messages

- Most candidates successfully attempted all the questions. The full range of marks was seen. The paper discriminated successfully between candidates of different abilities but was accessible to all. Candidates found the last question, **Question 4**, demanding.
- Most candidates were able to complete tables of results from readings on diagrams, as in **Question 2**.

General comments

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

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

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

Lists of answers with correct and incorrect responses are marked according to a list principle and 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 credit can be awarded.

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

Comments on specific questions

Question 1

(a) Some candidates were either unfamiliar with the common items of laboratory apparatus or did not look carefully at what was being labelled. **B**, the tripod, was often referred to as a Bunsen Burner or a stand, which was insufficient. **C** was often named as a filter, which was again insufficient as funnel was required. **A** was often referred to as a pestle or (grinding) bowl instead of a mortar.

(b) (i) Most candidates who attempted this question gained full credit. A significant number of responses were left blank, indicating that some candidates need to read question papers carefully and not just look for dotted lines on which to write their answers. The most common errors were to draw multiple spots above the baseline and the solvent front at the end of the experiment rather than the spot on the baseline and the level of the solvent below the baseline in the beaker.

(ii) This was generally well-answered with most candidates realising that graphite is insoluble.

(c) (i) The most common answer given was 'three' with some candidates incorrectly identifying the substances as red, blue and green. Only a minority of candidates realised that as there were two spots on each chromatogram there must be just two coloured substances obtained from the berries.

(ii) This was generally well answered but confused answers were common, with some candidates suggesting an indicator that was not in the table.

Question 2

(a) The table of results was often completed correctly when reading the thermometer diagrams or calculating the temperature changes. The most common errors were reading the fourth initial temperature as 22 °C rather than 22.5 °C or the first temperature after one minute as 19 °C rather than 19.5 °C. All readings should have been given to the same number of decimal places. Many candidates incorrectly gave readings to a mixture of zero and one decimal places.

(b) Most plotted the points correctly but often not clearly. A common error was to plot the point for 5 g at 4 g. Some candidates only read the instructions that the lines used should have been straight and extended until they met each other after they had already drawn curves.

(c) (i) A significant number of candidates did not show clearly on the grid how they worked out their answer and/or missed out the units.

(ii) Better performing candidates realised that the acid had become the limiting factor and that excess sodium hydrogencarbonate was present. Vague answers such as ‘the reaction finished/stopped’ were common and received no credit.

(d) Candidates found this a demanding question. If the acid used had half of the original concentration, then all the acid would have been reacted with just half of the mass of sodium hydrogencarbonate as compared to the original investigation. If half the mass of sodium hydrogencarbonate reacts then the temperature decrease would be half the original decrease. Very few correct answers were seen. Some candidates realised that the mass of sodium hydrogencarbonate required would be half the original mass.

(e) Many candidates stated that a burette or pipette would be more accurate than a measuring cylinder. Fewer candidates realised that insulation would reduce heat gain from the surroundings. A common error was to suggest stirring with something other than a thermometer or to suggest repeating the experiment and finding a mean. The latter was not acceptable as the question specifically asked for a change to the apparatus.

Question 3

(a) The majority related the observations to the fact that solid **E** must be hydrated. Weaker responses gave observations rather than a conclusion.

(b) Candidates were required to realise that the negative test result meant that solid **E** was not a halide. There was some confusion between the terms halogen and halide.

(c) Common errors were to identify the ions present as zinc, by not understanding **test 4** and nitrate, by confusing the test for ammonium ions and nitrate ions as they both produce ammonia gas. Identifying the ion as ammonia showed a lack of knowledge and understanding.

(d) The expected observation was a yellow/orange flame, but many candidates thought a precipitate would be formed or that there would be a squeaky pop. The latter response showed confusion between a flame test for cations and using a lighted splint as a gas test.

(e) (i) Most candidates gave an acceptable colour for universal indicator in an alkaline solution such as blue or purple.

(ii) A minority of candidates understood that this was the test for copper ions using aqueous sodium hydroxide forming a blue precipitate.

Question 4

A number of candidates unnecessarily spent time explaining, often in detail, how to collect the volume of gas produced using a gas syringe despite the information given in the stem of the question.

The candidates were told they had to use the information shown in the diagram. This meant that the plans had to be based on the mass lost during the reaction.

The most common methods used were to measure the mass lost in a specified time or to measure the time taken until the mass of the flask and contents stopped changing.

Some candidates opted to measure the mass lost when the mass stopped changing without measuring the time. This last method could not gain full credit as the final mass lost will be the same whatever the rate of reaction, as was the case for using methods that were not based on the loss in mass.

In order to produce valid results, each run at a different temperature should have the same mass of calcium carbonate and the same volume of acid.

It should be noted that 'amount' is not an acceptable term for mass or volume. As the independent variable is the temperature of the acid, experiments must be conducted using acid at different temperatures. However, the acid should not be heated so that its temperature is changing while it is reacting.

In all methods, timing is necessary and so an instruction as to when a timer is started was expected. Once a final measurement has been made, (be that mass lost in a set time or the time taken to stop reacting or lose a set mass), then there should have been an explanation of how the differences in that measured quantity relate to the rate of the reaction.

A minority of candidates did not attempt the question.

CHEMISTRY

Paper 0971/62
Alternative to Practical 62

Key messages

- The 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.
- **Question 4** was a planning task based on the percentage of water in hydrated magnesium sulfate. Nearly all candidates used a valid method, even if a few details were missing.
- The majority of candidates were able to complete tables of results from measuring cylinders on diagrams in **Question 2**, although some problems were caused by the fact that the measuring cylinder was inverted.
- Some responses might suggest that candidates have limited practical experience.

General comments

Observations are those which you can see. For example, 'fizzing' is an observation, whereas 'a gas was given off' is not.

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

Comments on specific questions

Question 1

(a) The two pieces of apparatus that had to be identified were well known; a glass or stirring rod and a conical flask.

(b) The process of filtration was very well known.

(c) The term 'filtrate' for the solution obtained after filtration was given by some candidates, with the rest using more general terms such as 'solution' or the name of a specific solution.

(d) Most candidates answered this question very well. Good responses realised that after filtration the residue needed washing and drying. The most common error was to assume that it was in solution and to describe the process of crystallisation

Question 2

(a) Nearly all candidates filled in the column with the volumes of hydrochloric acid correctly. Most could also read the inverted measuring cylinders correctly, although the inversion did cause problems for some. Readings should be recorded in a consistent manner in terms of decimal places.

(b) Graph work was excellent, with many gaining full credit. The scale of 10 cm^3 per 2 cm was used by nearly all; the points were plotted correctly and a good straight line of best fit was drawn. A small number of candidates chose unsuitable scales such as 3, 6 or 7 units to each 2 cm square. This caused difficulty in both plotting and reading the graph. Graph scales should be chosen such that the plotted data takes up over half of the available space and it is recommended that each major grid line should be equivalent to 1, 2, or 5 (or those numbers multiplied by 10^n) – this is indicated in the mathematical requirements in the syllabus and by the Association for Science Education (A.S.E.).

(c) (i) This question was well answered, with most candidates showing their working on the grid.

(ii) Nearly everyone could get the correct answer by dividing by 7. A few showed rounding errors or chose a different point from that asked for in the question.

(d) (i) Most realised that gas would escape if the bung was not replaced very quickly.

(ii) Candidates found this a challenging question. The ideal answer was to have the sodium carbonate in a separate container in the boiling tube/flask and to shake or tilt it to start the reaction. Many suggestions involved a burette or separating funnel or syringe being added through a second hole in the bung to introduce the acid. Whilst this would prevent the escape of gas it would also affect the volume of gas recorded as air is displaced by the acid. Whilst this method was rewarded, it could not get gain full credit.

(e) Nearly everyone knew that the burette was more accurate than the measuring cylinder.

(f) Candidates were asked to sketch a second line on the grid for acid of half the original concentration. Most realised that it would be below the original and many drew it at exactly half the original values.

Question 3

(a) Oxygen was correctly identified by nearly everyone.

(b) Better responses correctly identified calcium iodide, with others often getting one of the ions, usually the iodide, correct. Magnesium was allowed instead of calcium as, although not mentioned in the syllabus, it would give the same results.

(c) Candidates found describing the changes observed when hydrated copper(II) sulfate was heated challenging. Marking was generous in descriptions of steam and condensation, although the most common correct observation was the colour change from blue to white. Candidates should remember that 'water is formed' is not an observation, but 'droplets of water are formed' is.

(d) The flame colour for copper was well known; blue-green was the expected answer. A few candidates were not familiar with a flame test.

(e) The reaction with ammonia was very straightforward because it was with a copper(II) compound. Responses involving a pale blue precipitate followed by a dark blue solution were common.

(f) The white precipitate with barium nitrate was very well known.

Question 4

Candidates were required to calculate experimentally the percentage of water in epsomite (hydrated magnesium sulfate). The method used by the majority was to remove the water by strongly heating the crystal, although a minority successfully condensed and weighed the water.

With the mass loss method, most knew to weigh before and after strongly heating the sample and went on to describe how the results should be used. The missing details were commonly a suitable vessel for strongly heating, such as a crucible, and the idea of heating to constant mass.

Candidates using the collection of water method often used an unsuitable container, such as a beaker. Fitting a condenser to a beaker would be challenging. However, the idea of heating until no more water was collected was seen more often.

A few included extra incorrect steps such as washing the residue before weighing.