CHEMISTRY

Paper 0971/11
Multiple Choice (Core)

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

General comments

Candidates performed reasonably well on this paper.

Comments to specific questions

Questions 14, **25** and **32** proved to be particularly straightforward.

Questions 7, **10** and **18** proved to be more difficult.

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

Question 1

Response **B**. Candidates did not realise that, at this temperature sodium chloride is not solid.

Question 3

Response **A.** Candidates knew a filter paper was needed but picked the wrong solvent.

Question 10

Response **D**. This response was more popular than the correct one. Candidates knew the products but missed the wrong electrodes.

Question 11

Response **B** This response was again more popular than the correct one. This is a common error where candidates think that, because energy is absorbed, the temperature of the surroundings must go up.

Question 18

Response **A**. This response was again more popular than the correct one. Candidates did not realise that evaporating the mixture would mean that the salt was contaminated with sodium hydroxide.

Question 29

Response **B**. Candidates realised that 1 and 3 caused pollution but not that carbon monoxide does not cause acid rain.

Question 33

Response **A**. Candidates knew that limestone is calcium carbonate but did not know this process.

Question 38

Response **B**. Candidates knew it could be made by fermentation but did not understand the meaning of 'unsaturated'.

Question 40

Response **D**. Candidates ignored the word 'polymers'.

Questions 5, **6**, **17**, **19**, **21**, **26** and **31** had approximately equal numbers of candidates selecting each response. This indicates that many candidates were guessing.

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Paper 0971/21
Multiple Choice (Extended)

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

General comments

Candidates performed well on this paper.

Questions 1, **2**, **7**, **14**, **22**, **28**, **32** and **36** proved to be particularly straightforward.

No questions proved to be particularly difficult.

Comments on specific questions

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

Question 5

Response **B**. Candidates knew about shared electrons but were confused by the second statement.

Question 18

Response **B**. Candidates did not realise that Y was a metal even though it was positioned towards the right of the Periodic Table.

Question 19

Response **B**. Candidates confused 'weak' with 'dilute'.

Question 20

Response **A**. Candidate mistook A for an alkali metal and did not think further.

Question 24

Response **A**. Candidates did not know that alloys are mixtures not compounds.

Question 33

Response **D**. Candidates picked the correct catalyst but chose the conditions for the Haber process.

Question 34

Response **A**. Candidates knew that limestone was calcium carbonate but were not familiar with this process.

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Paper 0971/22
Multiple Choice (Extended)

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

General comments

Candidates performed very well on this paper.

Questions 1, **4**, **7**, **14**, **19**, **20**, **21**, **23**, **26**, **27**, **29** and **30** proved to be particularly straightforward.

Question 8 proved to be particularly difficult.

Comments on specific questions

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

Question 5

Response **B**. Candidates knew about the shared pair of electrons but were confused about the second statement.

Question 8

Response **C**. This response was more popular than the correct one. Candidates did not realise 2 moles of NaOH neutralise 1 mole of sulfuric acid.

Question 11

Response **C**. Candidates did not know about fuel cells and answered about a combustion engine.

Question 17

Response **A**. Candidates clearly did not know about neutral oxides.

Question 18

Response **B**. Candidates failed to spot that Y is a transition metal.

Question 22

Response **B**. Noble gases are monatomic. Candidates did not realise this.

Question 33

Response **D**. Candidates picked the correct catalyst but chose the reaction conditions of the Haber process.

Question 38

Response **A**. Candidates wrongly thought that ethanoic acid decolourised bromine water.

CHEMISTRY

Paper 0971/31
Theory (Core)

Key messages

It is important that candidates read the stem of the question carefully in order to understand what exactly is being asked.
Some candidates need more practice in answering questions involving salt preparation and qualitative tests.
Many candidates need further practice in answering extended questions.
Interpretation of data from tables and graphs was generally well done, as was completion of simple symbol equations.

General comments

Some candidates tackled this paper well, showing a good knowledge of core Chemistry. Nearly all candidates were entered at the appropriate level. Many candidates answered every part of each question. The exceptions were **Questions 2(d)(iii)**, **4(e)**, **5(a)(ii)**, **6(a) and 7(b)(iii)** where a significant number of candidates did not respond. The standard of English was generally good.

Some candidates need more practice in reading and interpreting questions. In some questions, the rubric was misinterpreted or ignored by a significant number of candidates. For example, in **Question 2(e)**, many candidates gave answers which only referred to transition elements rather than metals in general. In **Question 3(a)(ii)**, many candidates did not take note of the word 'non-metal' in the stem of the question. In **Question 3(c)(i)**, some candidates did not refer to the electronic structure. In **Question 4(a)**, some candidates wrote about general properties of solids and gases and did not refer to the kinetic particle theory as requested in the stem of the question. Candidates might be advised to learn how to read the stem of the question carefully in order to get the correct interpretation of what is being asked.

Many candidates need practice in answering questions relating to qualitative analysis and the preparation of salts. Some knew the test for iodide ions in **Question 4(e)**; many did not know the correct reagent that should be used. A minority of the candidates knew the result of the test to distinguish between methane and ethene in **Question 5(a)(iii)**. Most candidates need practice in describing the preparation of salts and understanding the stepwise processes involved.

Some candidates need more practice in writing specific answers rather than providing vague, unqualified statements. For example, in **Question 1(b)** (definition of an element), many wrote vaguely about 'same sort of atoms' or 'substances in the Periodic Table'. In **Question 3(a)(iii)**, some candidates wrote about groups of elements rather than singling out specific elements. In **Question 4(b)**, some candidates just wrote a single word 'decreases' instead of describing that the volume decreases as the pressure increases.

A minority of the candidates wrote good answers to the extended **Questions 4(a)** and **6(a)**. Others did not organise their work and seemed to write their answers down in a disordered fashion as the ideas came to them. Some candidates need more practice in answering questions about salt preparation. Candidates should be encouraged to answer these questions as a series of bullet points.

Many candidates were able to extract information from tables and diagrams. Others need more practice in answering questions involving graphical work. For example, in **Question 7(b)(iii)**, many candidates need more practice in interpreting given information and drawing a graph line carefully so that it does not involve unnecessary large humps or dips.

Many candidates were able to undertake simple calculations involving relative formula mass and calculations involving simple proportion; others need to revise these areas.

Questions involving general chemistry including, atomic and molecular structure, balancing symbol equations and the structure of organic molecules were generally well known.

Comments on specific questions

Question 1

This was one of the best answered questions on the paper. Many candidates identified at least three of the structures correctly in **(a)** with **(iii)**, **(v)** and **(vi)** often being correct. Fewer gave a convincing definition of an element in **(b)**.

(a) (i) Some candidates identified the covalently-bonded structures of diamond and nitrogen. The commonest errors were to suggest **C** (lithium chloride) and/or **E** (copper).

(ii) A minority of the candidates identified a diatomic molecule. The commonest incorrect answer was **B** (diamond). Other candidates suggested **C** (lithium chloride).

(iii) Many candidates identified the structure **C** as a compound. The commonest incorrect answer was to suggest **A** (helium).

(iv) A minority of candidates identified **C** lithium chloride as soluble in water. The commonest error was to suggest **B** (diamond).

(v) This question was answered well. Many candidates recognising that diamond is used for cutting tools. The commonest error was to suggest **C** (lithium chloride).

(vi) This was the best answered of the **(a)** questions. The commonest error was to suggest B (diamond).

(b) Few candidates were able to define the term *element* with sufficient precision. The best answers referred to all the atoms having the same number of protons or the fact that there was only one type of atom present. Others suggested that an element cannot be broken down into another substance without including the essential phrase ‘by chemical means’. Many wrote statements that were too vague e.g. ‘a substance with the same atoms in it’. This could refer for example to methane and ethane, which both have carbon and hydrogen atoms. Others did not gain credit because they referred to molecules containing the same types of atom – a definition of a diatomic molecule rather than an element. A considerable number of candidates gave examples of elements e.g. nitrogen in place of a general definition.

Question 2

Many candidates were able to balance the equation in **(b)** and to explain the oxidation of carbon in **(c)**. Some candidates were able to give two general properties of metals in **(e)**. Others gave properties that were specific to either transition elements or Group I metals. Part **(d)** was the least well answered. Few candidates recognised the thermal decomposition reaction or the basic character of calcium oxide.

(a) Some candidates gave the correct name of an ore of iron. The commonest error was to suggest bauxite. Others gave non-specific names such as ‘iron ore’ or just ‘metal ore’. A significant minority gave properties such a ‘high melting point’ rather than the name of an ore.

(b) Most candidates balanced the equation correctly. The commonest error was to suggest O or 2O instead of O_2.

(c) Many candidates were able to explain why carbon was oxidised by referring to the equation. Others wrote statements that were too vague such as ‘the carbon changes to carbon monoxide’ or ‘the carbon ends up with oxygen’. Some candidates did not refer to the equation as instructed and just gave a definition of oxidation.

(d) (i) Few candidates recognised the reaction as thermal decomposition. Some realised that it was a decomposition reaction but omitted the word ‘thermal’. Others gave ‘exothermic’ or ‘endothermic’. A majority of the candidates gave incorrect answers such as ‘oxidation’ or ‘melting’.

(ii) A minority of the candidates gained full credit for recognising that calcium oxide is a basic oxide and relating this to the metallic nature of calcium. The commonest incorrect answers were 'metal oxide' or 'Group II oxide'. Some tried to explain the basic nature by referring to the reaction of calcium with water. Some candidates thought that calcium was a non-metal. A significant number of candidates did not respond to this question.

(e) Some candidates were able to give two general properties of metals. Few gave three correct properties. A common error was to give properties of transition elements such as high density or high melting point or to refer to coloured compounds. Others gave properties of Group I elements such as low density, low melting point or reference to cutting with a knife. The best answers referred to electrical conductivity and lustre (shiny).

(f) Many candidates counted the number of atoms correctly. Fewer were able to translate the numbers into a correct formula. Many just wrote the numbers down as iron 2, carbon 9 and oxygen 9 or Fe2 + C9 + O9. Another common error was to write the formula as Fe_2CO_9. A significant number of candidates miscounted the oxygen atoms.

Question 3

This was the best answered question on the paper. Many candidates gained full credit for **(a)(i)**, **(a)(ii)** and **(b)**. In **(a)(iii)**, many candidates either gave too generalised answers or did not read the question fully. Part **(c)** was answered well by some candidates. Others gave vague answers to **(c)(i)** or gave uses of other noble gases in **(c)(ii)**.

(a) (i) Most candidates deduced the correct percentage of the other elements present in the Earth. The commonest error was to give very large numbers by multiplying some of the figures instead of undertaking a subtraction from 100.

(ii) Many candidates identified oxygen correctly. The commonest error was caused by not reading the stem of the question carefully enough and suggesting iron, which has the highest percentage but is not a non-metal. Silicon was another incorrect answer that was commonly seen.

(iii) Some candidates gave two correct differences in the percentage by mass. The best answers focused on the differences in the composition of helium, hydrogen or iron. Many candidates just repeated the percentages in the table without writing that one was a greater percentage than another. e.g. 'There is 0.1% hydrogen on Earth and 76% in the Universe'. Many candidates gave answers that were too generalised such as 'there are more non-metals in the Universe' or 'there are more gases in the Universe and less in the Earth'.

(b) A majority of the candidates completed the diagram to show the electronic structure of an oxygen atom. The commonest errors were either to add another ring of electrons or to draw four electrons in the outer shell. A minority of candidates drew an inner shell with four electrons or an outer shell with eight electrons.

(c) (i) Some candidates explained the unreactive nature of neon in terms of a full outer shell of electrons or eight electrons in the outer shell. Others did not mention the outer shell or did not heed the command word *explain* and gave simplistic answers such as 'it is in Group 8 of the Periodic Table'. A significant number of candidates wrote about low melting or boiling points rather than concentrating on the electronic structure.

(ii) Many candidates gave a suitable use for argon. The best answers referred to lamps or lighting. A common misconception was that argon is used for the filament in the (old fashioned) light bulb. Many candidates muddled argon with helium and suggested that argon is used in balloons or airships.

Question 4

Many candidates were able to explain the shape of the graph in **(b)** and to balance the equation in **(d)(i)**. Parts (**c)(ii)** (relative reactivity of the halogens), **(d)(ii)** (explaining the energy level diagram) and **(e)** (describing the chemical test for iodide ions) were the least well answered.

(a) Some candidates gave good answers and described both the separation and motion of the particles correctly. Others wrote about separation or motion, but not both. The commonest omission was not to write about the degree of separation of the particles in the gas. Some answers were rather vague e.g. 'the particles in the gas move more than in the solid'. Some candidates wrote about the general properties of solids and gases without reference to particles e.g. 'the particles in the solid have a fixed shape'.

(b) Most candidates described how the volume of gas changes as the pressure increases. A minority of the candidates wrote answers that were not specific enough e.g. 'it decreases with pressure'. Candidates should be encouraged to write the direction (increase or decrease) of both volume and pressure. The best answers suggested that volume decreases as the pressure increases.

(c) (i) Some candidates gave the correct reactants. Others recognised one of the reactants but made naming errors such as potassium iodine or bromide. Other common errors included the suggestion of interhalogen compounds such bromine iodide or to repeat the products iodine and potassium bromide as the reactants. A significant number of candidates included chlorine compounds in the equation, even though there was no chlorine in the products.

(ii) Few candidates explained the reaction in terms of the reactivity of the halogens. Common errors were to compare the relative reactivity of potassium with one of the halogens; to state that chlorine is above iodine in Group VII without reference to reactivity; to state that iodine is not very reactive or that potassium is very reactive; to suggest that both iodine and potassium chloride were unreactive.

(d) (i) Most candidates balanced the equation. The commonest error was to suggest 4NaI.

(ii) The best answers compared the relative energy levels of the reactants and products. The commonest error was to give a definition of exothermic rather than interpreting the diagram.

(e) Few candidates knew the qualitative test for iodide ions. A greater number knew that a yellow precipitate would be formed. Common errors included the use of sodium hydroxide, ammonia or barium nitrate for the test reagent and a white precipitate for the result. Other candidates suggested a starch test, mistaking iodine for iodide ions. Some suggested adding chlorine or suggested changes in physical properties. A considerable number of candidates did not respond to this question.

(f) Some candidates identified iodine as the electrode product. The commonest incorrect answers were sodium or iodide.

Question 5

This question was the least well answered on the paper. Most candidates were able to identify the alkane in **(a)(i)**. Few candidates were able to draw the correct structure of ethene in **(a)(ii)** or explain how aqueous bromine can be used to distinguish methane and ethene in **(a)(iii)**. In **(b)(iii)**, most candidates did not focus on the bio- in the phrase non-biodegradable and gave generalised answers. In **(b)(iv)**, many gave imprecise answers to the question about the pollution problem caused by non-biodegradable plastics. Few knew the other reactant needed to make ethanol from ethene in **(c)**, although more stated a correct condition.

(a) (i) Most candidates identified methane. The commonest errors were to suggest either ethene or carbon monoxide.

(ii) Some candidates drew the structure of ethene correctly. The commonest errors were to draw a C=C double bond but keep three hydrogen atoms on each carbon, to omit the double bond or to draw the structure of propene (often incorrectly). Others drew structures that included oxygen or omitted hydrogen atoms.

(iii) Few candidates described how aqueous bromine is used to distinguish ethene from methane. Many only mentioned the effect of bromine on ethene and ignored the effect on methane. Others mentioned incorrect colour changes or referred just to double and single bonds or saturated or unsaturated hydrocarbons rather than describing the observations on adding bromine. A few wrote vague statements about functional groups. A considerable number of candidates did not respond to this question.

(b) (i) Some candidates realised that the name of the type of reaction was polymerisation. Others gave the general name of the substance formed (polymer) or the name of the specific substance formed (poly(ethene)). Other common errors included 'thermal decomposition', 'reduction' or 'oxidation'.

(ii) Many candidates identified monomers as the correct answer. The commonest error was to suggest 'polymer'. A few candidates selected 'mixtures'.

(iii) Very few candidates explained the term non-biodegradable. Better responses referred to lack of bacterial, fungal or biological action on the plastic. Most suggested that the plastic does not break down without any further detail. Others did not heed the word 'non' in the phrase 'non-biodegradable' and wrote about the plastics breaking down. Many wrote about landfill sites or litter.

(iv) The best responses gave full answers such as 'the plastic blocks drains and leads to flooding' or 'the plastic gets stuck in the digestive system of animals and they die'. Others did not write in enough detail and did not mention the consequence of the actions. Many just mentioned waste or litter. Others wrote about not recycling or reusing, which does not answer the question.

(c) Many candidates thought that the question was about fermentation rather than the addition of steam to ethene. Many suggested alcohol, glucose or oxygen instead of steam as a reagent. The conditions often included incorrect statements about enzymes and room temperature. The most commonly awarded mark was for the suggestion of high temperature as a condition.

Question 6

Some candidates performed well on this question, especially in **(b)(i)**, **(c)** and **(d)**. Fewer candidates gave a convincing description of the preparation of a salt in **(a)** and many gave imprecise descriptions about alloys in **(e)**.

(a) The best answers for the salt preparation included heating the mixture, filtering and heating the filtrate or the solution to the point of crystallisation. Many candidates did not suggest heating the mixture of copper oxide and sulfuric acid and few mentioned filtering. Many of those who did mention filtering, filtered the wrong substance – many thought that the copper(II) sulfate was the residue on the filter paper at this stage. Others were unclear what was being crystallised or gave the implication of heating to dryness. A considerable number of candidates did not respond to this question.

(b) (i) Most candidates recognised a reversible reaction. The commonest errors were to suggest that it was either the backward reaction only or that it was an equal sign in the equation.

(ii) The best responses gave the simple answer 'heat it'. Others suggested removing the water but did not explain how it could be removed. Many suggested adding water or hydrogen or gave vague answers referring to reversible reactions.

(c) Many candidates carried out the calculation successfully. The commonest errors arose either from not including all the results in the addition of the last column or incorrect multiplication. Another common error arose from not multiplying the molar mass of the oxygen by 4, giving the incorrect result of 112.

(d) The commonest errors seen were: 29 for the number of electrons in the Cu^{2+} ion (not taking into account the 2+ charge); 18 for the number of protons (number of neutrons calculated rather than number of protons) and 34 and 63 for the number of neutrons (mass number taken).

(e) (i) The best answers mentioned a mixture of a metal with another element. Many candidates did not state that an alloy is a mixture. Others suggested that an alloy was a mixture of metals or a mixture of non-metals.

(ii) The best answers used comparative terms e.g. 'the alloy is stronger'. Errors often arose because candidates made incorrect statements about the copper or the alloy e.g. 'copper is soft and the alloy is hard'. Many candidates wrote about differences in cost or reactivity. Reactivity is unacceptable because it depends on the nature of the alloying atoms. Many candidates wrote about rusting, which was not accepted since this only relates to iron.

Question 7

This question was one of the least well answered on the paper. Many candidates named the salt in **(a)** correctly and deduced the loss in mass in **(b)(ii)** and **(b)(iv)**. Few gave a good reason why the mass of the reaction mixture decreases in **(b)(i)**. Many candidates drew the line in **(b)(iii)**.

(a) Many candidates identified the salt as calcium chloride. Some wrote carbon dioxide and water as well. The commonest errors were calcium hydroxide or a made-up name such as 'calcium hydrochloride carbonate'. The latter type of answer suggests that these candidates are not identifying the salt but are conflating the products. A significant number of candidates suggested sodium chloride.

(b) (i) The better responses realised that the gas which escapes has a mass and so the overall mass of the reactants and vessel decreases. The commonest errors were either to refer to evaporation of the contents of the flask or evaporation of the acid or to write vague statement about mass of the products or reactants decreasing with time.

(ii) Some candidates realised that subtraction of 199.3 from 200.0 was required and gave the correct answer. Others just read the value on the graph and gave the incorrect answer 199.3.

(iii) The best answers showed a line of steeper gradient, which clearly started at 200.0,0 and levelled off at 199.0 g before 100 s. Many candidates drew lines with a shallower gradient, but which did level off at the correct value. Others drew lines with a steeper gradient, which did not level off at 199.0 g or reached the line after a dropping well below 199.0 g. Candidates should be advised to draw their lines carefully so that there are no significant bumps in them. A considerable number of candidates did not respond to this question.

(iv) Many candidates calculated the loss of mass of calcium carbonate correctly. Others gave the answer 0.44 (dividing 0.88 by 2) or tried to do partial mole calculations. Candidates should be advised that there are no mole calculations in this sort of question in the core paper, only calculations involving simple proportion.

(v) Some candidates deduced the order of size of the pieces of calcium carbonate correctly. Others either inverted the order or, more commonly, did not realise that there should be a relationship between rate and size. Some candidates put numbers in the left-hand column rather than size of particles. Sometimes these numbers were the inverse of the rate. This suggests that these candidates did not read the stem of the question.

Question 8

This question was well answered by some candidates. Most candidates gave good answers to **(a)(ii)**, **(a)(iii)** and **(d)**. Others did not appreciate the meaning of the word 'source' in the stem of the question in **(a)(i)** or give a suitable adverse effect of sulfur dioxide on buildings in **(a)(iv)**. Some candidates answered **(b)** and **(c)** well. Others need more practice in writing with precision in questions requiring explanations and in naming salts formed from ammonia.

(a) (i) The best answers suggested burning fossil fuels or from volcanoes. Many candidates gave answers that were too vague e.g. 'pollution', 'from factories'. Others did not appear to understand the meaning of the word 'source' and gave answers such as 'it's a toxic gas' or 'it forms acid rain'. A considerable minority of the candidates gave carbon dioxide as a source of sulfur dioxide, despite the lack of sulfur in the former.

(ii) Most candidates understood that catalysts speed up the rate of reaction. A few candidates just mentioned that they change or slow the rate. This is not sufficient for an answer; a substance which decreases the rate of reaction is an inhibitor.

(iii) A majority of the candidates gave the correct pH value. The commonest error was to suggest pH 13. A few chose pH 7.

(iv) Few candidates gave a good explanation of the effect of acid rain on buildings. The best answers used the terms *corrodes* (metalwork) or *erodes* (stonework). Most candidates suggested, incorrectly, more drastic effects such as 'destroys them', breaks them' or 'the building collapses'. Many suggested effects on paintwork or on colour. Others suggested that it speeds up rusting. Candidates should be advised to use the term *rusting* only with respect to the reaction of water and oxygen with iron.

(b) Many candidates correctly deduced that sulfur dioxide is liquid at –20 °C. Fewer gave a full reason for this. Some mentioned higher than melting point or lower than boiling point but only a minority mentioned that –20 °C is between the melting point and boiling point. Many wrote vague partial answers that referred to 'not reaching the boiling point' or 'it's near the boiling point'.

(c) A minority of the candidates correctly identified the salt as ammonium sulfate. Common errors included 'ammonia sulfate', 'ammonium hydroxide' or fabricated names such as 'nitrogen hydrogen sulfide'. Some candidates suggested sodium chloride, despite the fact that there is no sodium or chlorine present in either ammonia or sulfuric acid.

(d) Many candidates interpreted the order of reactivity from the table. A few candidates put the word 'metal' in one of the boxes rather than one of the named elements. Candidates should be advised that they should be able to discriminate between the heading of a table and the contents of a table.

CHEMISTRY

Paper 0971/41
Theory (Extended)

Key messages

Candidates must read questions carefully to ensure that the answer they give addresses what has been asked. Responses seen in **Question 3(c)** where chemical properties were asked for, but physical properties were given and **Question 4(b)(ii)** where descriptions of the reactions rather than observations were given, were typical examples where candidates did not address the question.

When drawing organic structures, candidates should be aware that structures will require all bonds to be drawn and thus the valency of the atoms needs to be correct. Trivalent or pentavalent carbon 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.

If, for example, two properties are asked for such as in **Question 3(c)**, more than two properties should not be given as incorrect statements may contradict correct answers.

General comments

Most candidates appeared to be well prepared for this paper, with only a relatively small proportion who would have benefitted from being entered for the core level paper.

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

Candidates should be encouraged to learn the definitions in the syllabus, as these tend to be straightforward marks and are very accessible.

Very few candidates felt the need to write on extra pages. Any candidate who uses the blank pages should clearly identify which question they are answering.

Comments on specific questions

Question 1

(a) Most candidates were awarded both marks for this recall of a syllabus statement. A significant number of candidates only gave a vague reference to the location of protons. e.g. ‘in an element’. Some responses demonstrated a misunderstanding about the nature of sub-atomic particles and incorrect phrases such as ‘positive ions’ or ‘positive atoms’ appeared.

(b) (i) Most candidates performed well. A common error was to use the nucleon numbers of 24 and 26 for the numbers of neutrons.

(ii) The answer was usually correct; occasionally ‘isomers’ appeared.

(iii) There were many instances where the candidates provided the definition of isotopes, ‘same number of protons but a different number of neutrons’ rather than answering the question set.

(c) Very few responses gained no credit. Common errors were showing Be with a charge (typically +1 or +2), using a mass number for C*l* of 35.5 or simply just omitting mass and atomic numbers.

(d) Most candidates gained full credit; a number did not recognise the electronic structure of the sulfide ion was required and gave the electronic structure of the sulfur atom.

Question 2

(a) and **(b)**
Most candidates recognised the typical temperature graph and were able to state the melting point was 80 °C and that at boiling, the graph would become horizontal at 220 °C.

(c) Many answers indicated misunderstandings about what happens when a substance is melting. Some showed understanding that bonds or forces are being broken but did not relate that to heat or energy being supplied and vague responses such as 'the attractive forces were being broken down so that its state could change' were seen. Where candidates did refer to energy being used to break the attractive forces, only a minority went on to say that these forces were between molecules.

(d) This question proved challenging for many candidates. The idea of vibrating particles was often known; many candidates then went on to describe the change of particle behaviour after melting rather than up to melting.

(e) Most candidates realised that a melting point would decrease and a boiling point would increase when impurities are present.

(f) Sketching the cooling of the sample so it fitted within the given limits of temperature and time caused problems for many candidates. Numerous candidates, who had generally handled the data associated with heating up **Z**, did not include a horizontal line for the period of **Z**'s freezing. Other candidates displayed a weak command of graphical skills and drew incorrect horizontal lines at, typically, 60 °C and a final temperature of 0 °C .

Question 3

(a) The processes involved in the extraction of zinc were well known. Common errors associated with **step 1** were using zinc rather than zinc blende as a starting material, omitting roasting and using oxygen instead of air. The difficult equation was known by many candidates. **Step 2** enabled many candidates to compare the reduction with that which occurs in a blast furnace. However, this comparison led to erroneous responses about the removal of zinc where 'tapping off as a liquid' was frequently seen.

(b) The majority answered this correctly. Some incorrect suggestions for brass were seen including ZnCu, CuZn, Copper Zincate and tin.

(c) Some candidates did not understand the difference between physical and chemical properties and so provided physical rather than chemical properties. Many had the idea of coloured compounds and catalytic activity but occasionally the erroneous response of 'coloured elements' was seen.

(d) (i) Despite the instruction to state the full name, 'anhydrous' was almost invariably omitted from those who realised copper(II) sulfate was the compound used to test for water.

(ii) The colour change associated with the test for water was generally well known. 'Colourless' was a popular alternative offered for 'white'. 'Blue to pink' was often seen, showing confusion with cobalt(II) chloride.

(e) (i) The correct balancing of this equation was achieved by many candidates. Some candidates were tempted to amend formulae in order to achieve correct stoichiometry and incorrect substances such as KI_3 appeared.

(ii) Many candidates were able to state '+1' as the answer; others gave a vague 'positive' as the response and gained no credit.

(iii) Many candidates chose to ignore the instruction 'In terms of electron transfer'; those who addressed the question often correctly stated copper was gaining electrons.

(iv) Only the better performing candidates tended to realise that potassium iodide was responsible for the reduction process.

Question 4

(a) (i) Very few candidates kept to the syllabus definition of an acid being a proton donor and wrote at length of other properties of acids.

(ii) Despite 'proton donor' being written in **Question 4(a)(i)**, very few of these candidates were able to show ethanoic acid dissociating into a proton, despite an example of an acid dissociating into protons being given in the question. Better performing candidates were able to give the correct anion.

(b) (i) Many candidates did not appreciate the significance of the word *observations* and many answers provided no description of what would be seen, only statements about the process. Examples of such responses included 'quicker reaction' or 'stronger reaction'.

(ii) Many candidates correctly identified at least two conditions. Better performing candidates gave precise statements such as 'concentration of acids and surface area of calcium carbonate' rather than simply 'concentration' or 'surface area'.

(c) This question provided an opportunity for many candidates to gain full credit. The major difficulty, apart from calculating the number of moles of HCl, was correctly applying the stoichiometry to determine the number of moles of $MgCO_3$.

(d) Candidates found this question on salt preparation challenging.

(i) Most candidates knew that excess $MgCO_3$ was added to react with any HCl present, but poorly expressed responses sometimes implied that the reason was to make sure all the $MgCO_3$ reacts e.g. 'to make sure it all reacts'.

(ii) Only a minority realised that the rinsing associated with filtration was, in this case, done to retrieve the maximum yield of MgCl_2(aq). The common error was to state 'to remove any HCl – despite giving this exact response in **(i)**.

(iii) As the candidates now had a solution to deal with, filtration (included by many) was not needed. Simply evaporating, crystallising and drying the resultant crystals were the steps needed. Commonly, carelessly phrased answers were seen, that implied the saturated solution formed after heating was to be dried between two filter papers.

(e) (i) The knowledge that a precipitate is the product formed when two aqueous species react to form one insoluble product was not known by many. Vague responses about a solid forming gained partial credit, but it was evident many thought any solid in a reaction was a precipitate.

(ii) The knowledge behind this common laboratory test was not well known. Some candidates identified the nitrate as being a suitable silver salt. There were relatively few candidates who could write the formulae of all the missing species correctly. Consequently, the equation was rarely correct. Candidates were asked to name the silver salt and incorrect spellings of the name were common. Candidates who chose to give a formula risked losing the mark as only the correct formula could be credited.

Question 5

(a) This was well known.

(b) The concept of molecular formula was not always known and abbreviated structural formulae, such as $CH_2CHCH_2CH_2CH_3$ were often seen.

(c) Most candidates correctly identify **E**; a large proportion struggled to give a correct explanation. The misconception that the bonds in the molecules break when a substance boils was frequently evident in responses e.g. 'it has the highest number of covalent bonds, which would require more energy to break'. Other explanations often suggested that **E** had the 'largest number of molecules' showing confused terminology.

(d) Compound **A** was usually identified; the knowledge that rate of diffusion is linked to M_r was less well known.

(e) Most candidates were able to give the correct colour change; the reverse was also seen frequently. Some incorrect products were given, usually incorporating Br but retaining double bonds leading to pentavalent C atoms. Sometimes hydrogen atoms were missing, leading to trivalent carbon atoms. Incorrect responses, but with correct valencies, were seen such as: 1,1–dibromobutane, 1,4–dibromobutane and 2,3–dibromobutane.

(f) (i) Some candidates drew structures with incorrect numbers of bonds on C atoms. Generally, candidates appreciated that propan-1-ol and propan-2-ol would form. Candidates were asked to show every atom and every bond. Frequently, the hydroxy group appeared as –OH rather than –O–H. Poor connectivity cost some candidates marks e.g. OH–C.

(ii) Most candidates could access this question and there were many candidates who gained full credit. A common error amongst those who knew this industrial process was to state water, rather than steam, as the reagent. Some candidates opted to describe a fermentation process.

(g) (i) Addition (polymerisation) was known by most candidates. Additional was not accepted.

(ii) Many candidates struggled to correctly name this addition polymer as 'poly(but-1-ene)'.

(iii) Candidates realised that addition polymerisation included the breaking of the double bond, to form a single bond and that the rest of the structure would remain untouched. Many did not realise that they were completing an equation and omitted the use of a subscript 'n'.

(iv) Terminology associated with organic chemistry was not known and many candidates gave the molecular formula or structural formula rather than the empirical formula.

CHEMISTRY

Paper 0971/42
Theory (Extended)

Key messages

The use of fractions as numerical answers to calculations should be avoided.

Candidates should understand what the word 'observation' means and how to answer questions that ask for observations. They should describe:
- colour changes
- physical states i.e. solid, liquid or gas
- the formation of precipitates
- effervescence or bubbling when a gas is evolved.

It is unnecessary to give the names of substances when asked for observations or to give tests for gases, unless they are requested.

General comments

Substances that conduct electricity do so because they have either ions that are moving or electrons that are moving. The words 'free' and 'delocalised' are inappropriate when explaining why substances conduct electricity.

Candidates should be aware that when they are asked to draw the structures of two (or more) isomers it is a mistake to draw the same molecules in different ways e.g. back to front or with the longest carbon chain drawn at an angle.

When discussing collision theory of reaction rates, it is essential to refer to collision *frequency* as opposed to collisions alone.

Details of methods of preparation of salts and the reasons for each part of the procedure should be revised more thoroughly.

Comments on specific questions

Question 1

(a) This was the only part of **Question 1** that was not answered well. Nitrogen was a common answer. Natural gas was possibly confused with air.

(b) This was answered very well. Ethanol was seen occasionally as an incorrect answer, possibly illustrating some confusion between respiration and fermentation.

(c) This was answered very well. Iron(III) oxide was seen occasionally as an incorrect answer.

(d) This was answered extremely well. Ethanol was seen occasionally as an incorrect answer, possibly illustrating some confusion between respiration and photosynthesis.

(e) This was answered very well. Nitrogen was commonly seen amongst the small number of incorrect answers. There was possible confusion between greenhouses and fertilisers.

(f) This was answered very well.

Question 2

(a) (i) This was answered extremely well. There were no common incorrect answers.

(ii) The reason why the overall charge is zero is that isotopes contain equal numbers of protons and electrons. Therefore, the number of positive charges in an isotope is equal to the number of negative charges. Many candidates found it difficult to express this using the correct terminology. Common answers did not refer to protons or electrons.

(iii) Many candidates realised that the reason for isotopes of the same element having the same chemical properties was related to the fact such isotopes contain the same number of electrons. However, reference to the outer shell was less common.

(iv) Sodium ions have one positive charge because the number of protons they contain is one more than the number of electrons. Candidates found it difficult to express this precisely enough.

(b) (i) This was answered very well. Silicon(IV) oxide was seen occasionally, as were oxides of carbon.

(ii) This was answered extremely well.

Question 3

(a) (i) This was answered extremely well. Ionic and metallic were seen very infrequently.

(ii) It was essential to refer to weak forces of attraction *between molecules* in order to gain credit. The most common answer was that attractive forces between particles (without reference to molecules) are weak.

(iii) Substances conduct electricity if they contain charged particles that are moving. Many candidates incorrectly used the words ‘free’ or ‘delocalised’ as alternatives to moving.

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

(ii) This was answered quite well. Candidates should be aware that redox is a type of reaction. Oxidation only describes what one reactant undergoes, as does reduction. Neither oxidation nor reduction should be described as a type of reaction.

(c) There were some extremely good answers to this difficult equation. Many candidates were able to write the formula of sodium phosphate and carry out the balancing perfectly.

(d) This was answered extremely well.

(e) (i) Candidates gave a wide variety of descriptions of the term *base.* Only proton acceptor was acceptable.

(ii) Candidates found this equation difficult. The salt produced often was given the formula $(NH_3)_2SO_4$, as well as many others. The minority that wrote a correct formula for ammonium sulfate usually included other products such as water or hydrogen. It seemed that only a few candidates knew that the product was an ammonium salt and that the formula of the ammonium ion is NH_4^+.

Question 4

(a) Many candidates suggested that hydrogen is extracted from air. The question asked for the ‘source’, as opposed to naming the method of extraction.

(b) This question was answered quite well; very few candidates gained full credit as a wide variety of errors were seen. Catalysts increase the rate of both forward and reverse reactions in an equilibrium.

The question asked candidates to respond, ‘using only the words *increases*, *decreases* or *no change*’. Some candidates decided to ignore this instruction.

(c) (i) This was answered well. Similar physical properties were occasionally seen. Better performing candidates were aware that the words 'same' and 'similar' have different meanings.

(ii) Candidates are advised to draw all the carbon atoms in the longest carbon chain horizontally rather than with a bend. Many drew the same alcohol twice, thinking that they had drawn two different structures. There is no alcohol simply called propanol. The O-H bond was often missing on both structures.

(iii) The word 'structural' was often missing from structural isomer. Isotope was seen occasionally as was 'structural isotope'.

(d) (i) This was answered quite well with many names spelt correctly. Methyl ethanoate was an occasional incorrect answer.

(ii) This was answered quite well. Methanol and ethanoic acid were occasionally seen.

(iii) Candidates found this challenging. Many drew the ester in **(d)(i)** in a different way, usually backwards. Carboxylic acids were seen often.

Question 5

(a) This was answered very well. Some used a 1:6 mole ratio (for no obvious reason) giving an answer of 3.75 g. Some used a 1:5 mole ratio giving an answer of 3.125 g.

(b) This was the least well-answered question on the paper. Many assumed impurities were present, without any evidence in the question. Carbon dioxide escaping and even copper(II) sulfate vaporising were common errors.

It was common to see answers that stated, 'yield is less than 100%'. This was rewriting the question rather than answering it. The question is essentially asking '*why* is the yield less than 100%?'.

(c) Despite the request for observations, many answers gave names and/or explanations rather than observations. The presence of a solid and the absence of effervescence/fizzing/bubbling are the statements that were required, although rarely seen. Common incorrect errors were that the copper(II) carbonate stops dissolving or that a gas stops forming; neither is an observation.

(d) Correct reference to surface area was common. Collisions were referred to only occasionally. Less *frequent* collisions was mentioned even more rarely.

(e) Salts such as copper(II) nitrate and copper(II) chloride were more common than bases.

(f) This was answered very well.

(g) (i) There was much discussion of single and double bonds as found in saturated and unsaturated hydrocarbons, rather than saturated solutions. Those who answered in terms of solutions often stated that there is more solute than solvent (the words solute and solvent were often confused). Temperature was only mentioned occasionally.

(ii) The formation of crystals (or any solid) was only seen occasionally.

(iii) The removal of water *of crystallisation* by heating to dryness was only mentioned occasionally.

Question 6

(a) This was answered quite well**.** Colours of other halogens e.g. brown/green/purple were occasionally seen.

(b) (i) Candidates found this challenging. Some candidates gave the colour of chlorine rather than that of aqueous potassium bromide at the start. A variety of final colours was seen. Some gave the colour change the wrong way round.

(ii) This was answered quite well. Br and Cl were seen occasionally as the formulae of the halogens.

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

Question 7

(a) (i) This was answered quite well.

It oxidises/it oxidises itself/it is itself oxidising are all phrases that should be avoided. All are ambiguous and could mean that they are oxidised or that they oxidise other things.

'A reducing agent is oxidised' is the best way to express one version of the correct answer.

(ii) Oxidation and reduction were just as common as the correct answer. 'Electrolysis' and 'ionic reaction' were seen quite often.

(b) The standard of writing ionic half-equations has improved considerably. Ag^{2+} and unbalanced equations were seen occasionally.

(c) This was answered quite well. The reverse order was seen occasionally.

(d) It was essential that candidates made it clear whether they were referring to nickel or sodium in their answer. Chemical properties were mentioned occasionally.

(e) This was answered quite well. There were no common errors.

(f) (i) In some answers there was no form of nickel in either of the electrodes or the electrolyte. Some used copper and copper salts or graphite electrodes. Only aqueous solutions can be used as electrolytes in electroplating.

(ii) In some cases, **N** was drawn outside the electrolyte. A significant number of candidates did not attempt this question.

CHEMISTRY

Paper 0971/51
Practical Test

Key messages

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. Smooth line graphs should be curves with no straight-line sections and labelled as required.

Straight-line graphs should be drawn with a ruler.

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 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 as 'white solid forms' contradicts the correct answer.

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. 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**, less demanding than in previous years.

A small number of centres did not submit the required Supervisor's results.

Comments on specific questions

Question 1

(a) The table of results was often completed correctly. A common error was recording the values in cm instead of mm. Some candidates recorded fluctuating values instead of the general expected trend of increasing.

(b) Most plotted the points correctly but often not clearly. A common error was to plot the point for $4\,cm^3$ at $3\,cm^3$ and so all subsequent points were incorrect. Most candidates drew a straight line using a ruler, but some drew lines that had no relationship to the last three points. Others drew a straight line when a smooth curve was clearly more appropriate. Graphs with lines joining each point, cross to cross, giving a zig zag effect were penalised.

(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. A minority of candidates omitted the unit.

(d) Almost all candidates understood that the height of the solid was increasing.

(e) Using a burette instead of a measuring cylinder to pour the barium nitrate was a common correct answer. Many candidates just stated the use of a burette or pipette and scored no credit. A burette

was already used for the sodium carbonate. A small number understood that leaving the solids to stand for longer would be an improvement but could not articulate the idea of better compaction over time.

(f) Many candidates gave complicated methods based on weighing the reactants before and after the experiment, thinking this would tell them the mass of the product. These responses ignored the law of conservation of mass. Confused answers referred to filtration and then evaporated the filtrate and dried the crystals, which showed a lack of understanding.

Good answers referred to filtration of the solid and weighing the dry solid.

(g) A common mistake was to simply state 'repeat the experiment'. Once repeated, the results obtained need to be compared to the original results to check their reliability.

(h) Few candidates identified precipitation as the type of reaction. Common incorrect responses were neutralisation, evaporation, displacement and titration.

Question 2

Solution **F** was aqueous hydrochloric acid.

Solid **G** was calcium carbonate.

(a) The majority correctly identified the pH of hydrochloric acid in the range of 0–3. Evidence of guessing was seen.

(b) Candidates were required to realise that the gas produced was hydrogen and then give the test for hydrogen. The use of a lighted splint to test the gas was often missing with comments such as 'squeaky pop test' alone, scoring no credit. Many candidates did not record the observation of effervescence/bubbles or fizz.

(c) The expected observation was white precipitate formed. Some answers referred to no reaction.

(d) The expected observation was no reaction, but many candidates recorded that a white precipitate was formed.

(e) The appearance of solid **G** was correctly described by most candidates.

(f) Effervescence was often not described and only a minority managed to test the gas with limewater and obtain the correct result. References to glowing splints relighting and lighted splints popping were unexpected answers.

(g) Formation of a white precipitate was often described but only the better performing candidates recorded that the precipitate was insoluble in excess sodium hydroxide.

(h) This was well-answered, with no precipitate or very slight white precipitate correctly recorded.

(i) Partial credit was awarded for identifying the presence of a chloride or an acid. Full credit was gained for identifying hydrochloric acid.

(j) The identity of solid **G** as a calcium compound was common; many candidates thought it was calcium oxide or calcium chloride.

Question 3

The full range of marks was seen for this question. A number of candidates spent time explaining, often in detail, how to paint the nails or electroplate nails with zinc, despite being informed that coated nails were already provided.

Many answers showed a lack of detail with vague statements such as ‘add the nails to water’ with no idea of any suitable container or quantity of nails or mass of nails. Other candidates omitted using an uncoated nail or having little understanding of the time needed to leave the nails to rust. Times from a few hours to using a stopwatch to note the observations every 10 minutes were common.

Many candidates did not say what would need to be done to determine which coating is more effective, despite having given details of how to set up the investigation. Instead of looking at the nails and explaining how the results obtained could be used to answer the question, these candidates often simply predicted the results.

Marks were awarded for:

set number of nails/weigh nails
nails in a suitable container
add water
leave for a suitable time (1 week)
observe nails/compare/reweigh nails
repeat with other nails
nail with least rust/mass increase has best coating.

A minority of candidates did not attempt the question.

CHEMISTRY

Paper 0971/61
Alternative to Practical

Key messages

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

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

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

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.

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

General comments

The vast majority of candidates successfully attempted all of the questions. 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**, less demanding than previous years.

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

Comments on specific questions

Question 1

(a) Some candidates had difficulty identifying the gas jar. Measuring cylinder, gas cylinder and test-tube were common incorrect answers.

(b) Most candidates gained credit on this question. Some candidates incorrectly suggested that the gas jar should be replaced with a gas syringe or that the delivery tubes were wrongly positioned. The suggestion that the chlorine should be collected over water showed a lack of understanding.

(c) This was generally well-answered with most candidates realising that the sulfuric acid removed water or impurities from the chlorine. Some thought that the chlorine needed to be acidified/neutralised or that the chlorine was made in the second conical flask.

(d) Most candidates could recall the test for chlorine. The most common answer was to give a test for chloride ions rather than chlorine gas.

(e) Marks were awarded for realising that a fume cupboard was used because chlorine is toxic/poisonous. Confused answers were common, with candidates giving answers based on heat loss, corrosive acids and explosions.

Question 2

(a) The table of results was often completed correctly. A common error was incorrect measurement of the heights of the precipitates in one or more of the test-tubes, with a minority recording the values in cm instead of mm. Some candidates measured the height of the liquid above the precipitate.

(b) Most plotted the points correctly but often not clearly. A common error was to plot the point for 4 cm^3 at 3 cm^3 and so all subsequent points were incorrect. Most candidates drew two straight lines using a ruler, but some drew lines that had no relationship to the last three points. The *x*-axis was sometimes incorrectly labelled as 'test-tube number'; there could not be a test-tube zero. Some responses omitted the unit and/or the term 'volume'.

(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.

(d) Almost all candidates understood that the height of the solid was increasing but some did not comment on the fact that the heights remained constant in the last three test-tubes.

(e) Good responses referred to the heights of precipitate being the same as the last three test-tubes but did not give a clear explanation. Some excellent responses in terms of barium nitrate being the limiting reagent were seen. A number were unsure and suggested the heights remained the same and increased or decreased; these responses were penalised.

(f) Many candidates just stated use a burette or pipette and scored no credit. A burette was already used for the sodium carbonate and it would not be appropriate to use in place of a test-tube. Credit was given for comparison to the measuring cylinder used to measure the aqueous barium nitrate.

(g) Many candidates gave complicated methods based on weighing the reactants before and after the experiment thinking this would tell them the mass of the product; these responses ignored the law of conservation of mass. Good answers referred to filtration of the solid and weighing the dry solid.

(h) A common mistake was to just state 'repeat the experiment'. Once repeated, the results obtained need to be compared to the original results to check their reliability.

Question 3

(a) The majority correctly identified the pH of hydrochloric acid in the range of 0–3. Evidence of guessing was seen.

(b) Candidates were required to realise that the gas produced was hydrogen and then give the test for hydrogen. The use of a lighted splint to test the gas was often missing with comments such as 'squeaky pop test' scoring partial credit. Many candidates gave contradictory observations such as white precipitate, pungent smelling or coloured gases and missed the effervescence.

(c) The expected observation was white precipitate formed. Many answers referred to no reaction, which showed a lack of knowledge of the chloride test.

(d) The expected observation was no reaction, but many candidates thought a white precipitate would be formed.

(e) The identity of solid **G** was correctly given by most candidates.

Question 4

The full range of marks was seen for this question. A number of candidates spent time explaining, often in detail, how to paint the nails or electroplate nails with zinc, despite being informed that coated nails were already provided.

Many answers showed a lack of detail with vague statements such as ‘add the nails to water’ with no idea of any suitable container or quantity of nails or mass of nails. Other candidates omitted using an uncoated nail or having little understanding of the time needed to leave the nails to rust. Times from a few hours to using a stopwatch to note the observations every 10 minutes were common.

Many candidates did not say what would need to be done to determine which coating is more effective, despite having given details of how to set up the investigation. Instead of looking at the nails and explaining how the results obtained could be used to answer the question, these candidates often simply predicted the results.

Marks were awarded for:

set number of nails/weigh nails
nails in a suitable container
add water
leave for a suitable time (1 week)
observe nails/compare/reweigh nails
repeat with other nails
nail with least rust/mass increase has best coating.

A minority of candidates did not attempt the question.

CHEMISTRY

Paper 0971/62
Alternative to Practical

Key messages

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

When a question asks for the name of a chemical, a correct formula is always acceptable. However, if a candidate answers with an incorrect formula, then 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.

No question proved to be more demanding than the others; all discriminated equally well.

This session, **Question 4** was a planning task based on the extraction of copper from one of its carbonate ores. There were various acceptable methods, including reduction by carbon or a more reactive metal. Other methods also gained credit, such as dissolving the ore in an acid followed by either electrolysis or displacement.

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

Comments on specific questions

Question 1

(a) (i) Most candidates knew that a spatula would be used to add zinc oxide to hydrochloric acid. It was clear that a lot of candidates were not aware that zinc oxide was a solid.

(ii) The most common answer here was the correct one, a Bunsen burner; other answers, such as spirit burners and water baths, were acceptable.

(b) Many candidates knew unreacted zinc oxide would be visible once all the hydrochloric acid had been used up. Others assumed incorrectly that zinc oxide would fizz when it reacted.

(c) (i) Most candidates could explain what was meant by 'excess'. This was usually the text book definition 'more than enough', but the specific reference to step 3 meant that 'unreacted zinc oxide' was also accepted.

(ii) Nearly all responses stated that filtration would remove the excess zinc oxide.

(d) Most candidates realised that the three steps are evaporation, to crystallisation point, followed by cooling.

(e) Candidates found this a challenging question. There were many good answers, focussing on either that the reaction would not need heating or that you could tell when the acid was neutralised because the fizzing stopped. Weaker responses missed the key word 'method' in the question and answered in terms of observations or products.

Question 2

(a) Most candidates could read the stop-clocks correctly; although a minority gave the answers in terms of minutes and seconds rather than seconds alone.

(b) Nearly all candidates chose the most suitable scale for the *y*-axis, where each large square was 10 s. The points were usually plotted correctly; the first point was most likely to cause a problem as it was the only one not on a major grid line. The curve was generally well drawn.

(c) Most candidates successfully extrapolated their graph line and went on to correctly read the time, including the unit.

(d) (i) A large number of candidates realised that the length of the magnesium ribbon was a control variable and should not be changed. This was expressed in a variety of ways, notably in terms of fair testing.

(ii) Most candidates suggested that reducing the length of the magnesium ribbon would reduce the time taken to dissolve. A few did not read the question and answered in terms of rate.

(e) Better responses were in terms of measuring the volume of gas evolved at time intervals using a gas syringe. Other methods were acceptable, such as mass loss. Unfortunately, a large number missed the '**different** method' in the question and incorrectly investigated a different variable or suggested how to improve the accuracy.

(f) (i) The majority of candidates gave a correct answer here. Displacement, neutralisation, redox and exothermic were all acceptable answers.

(ii) Nearly all responses identified hydrogen correctly.

Question 3

(a) Most candidates realised that ammonium sulfate is white; there was a variety of incorrect colours.

(b) The colour change of cobalt(II) chloride paper was well known. A minority reversed the colours. Condensation was seen less frequently, despite the 'hydrated' in the question.

(c) The test for ammonia was very well known.

(d) Most answers referred to the white precipitate.

(e) The identity of solid **M**, iron(III) chloride, was known by many candidates.

Question 4

Candidates found this planning task more challenging compared with recent papers. There were three common routes through the process. The first was by reduction of the ore, either as one step or as two steps. The second was by dissolving the copper(II) carbonate in an acid and then either electrolysing the solution to obtain copper at the cathode or by using a more reactive metal to displace the copper.

Common errors in these methods were not to crush the ore at the beginning or to assume that it could be dissolved in water or an alkaline solution.

The most common incorrect method was to use the lump of ore as the anode in a method similar to the purification of copper. This would not work as the ore would not conduct electricity and therefore was unsuitable to use as an electrode.

Candidates would be well advised to plan their answers 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. It must be clear what each apparatus is being used for and so this must be mentioned in the method.