CHEMISTRY

Paper 0971/12
Multiple Choice (Core)

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

General comments

Candidates performed reasonably well on this paper.

Questions 3, **23** and **27** proved to be particularly straightforward.

Questions 16, **17**, **26**, **34** and **39** proved to be more difficult.

Comments on specific questions

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

Question 5

Response **B**. Candidates forgot about the inner pair of electrons in the nitrogen atom.

Question 6

Response **C**. Candidates seemed to misunderstand the ‘7’ in the nuclide.

Question 7

Response **A**. Candidates assumed that alloys are compounds; this was a common error. Response **A** was an equally popular choice as the correct one.

Question 11

Response **C**. Candidates knew that the two processes were different but confused ‘endo’ with ‘exo’. This appeared to be a poorly understood topic.

Question 12

This question had approximately equal numbers of candidates selecting each response. This indicates that most candidates were guessing.

Question 16

This question had approximately equal numbers of candidates selecting each response. This indicates that most candidates were guessing.

Question 17

This question had approximately equal numbers of candidates selecting each response. This indicates that most candidates were guessing.

Question 24

Response **D**. Candidates selected the answer having read the first two bullet points only. It is important to read the whole question.

Question 26

This question had approximately equal numbers of candidates selecting each response. This indicates that most candidates were guessing.

Question 30

This question had approximately equal numbers of candidates selecting each response. This indicates that most candidates were guessing.

Question 33

Response **B**. Candidates did not know the uses of sulfur dioxide listed in the syllabus. Response **B** was more popular than the correct one.

Question 34

This question had approximately equal numbers of candidates selecting each response. This indicates that most candidates were guessing.

Question 39

This question had approximately equal numbers of candidates selecting each response. This indicates that most candidates were guessing.

Question 40

Response **C**. Candidates knew the monomer but did not realise that the polymer was named poly(ethene), even though it is saturated.

CHEMISTRY

Paper 0971/22
Multiple Choice (Extended)

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

General comments

Candidates performed well on this paper.

Questions 2, **8**, **23**, **25**, **27**, **30**, **31** and **33** proved to be particularly straightforward.

Question 10 proved to be more difficult.

Comments on specific questions

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

Question 10

Response **A**. Candidates used the mass of calcium carbonate and not the mass of calcium oxide. Response **A** was more popular than the correct one.

Question 13

Response **C**. Candidates knew the processes were different but confused ‘exo’ with ‘endo’. This was a common error.

Question 14

Response **B**. Candidates knew that hydrogen and methane both produce energy but did not appreciate the question related to a fuel cell.

Question 16

Response **D**. Candidates did not read the question properly and answered as if the factor being changed was temperature.

Question 38

Response **B**. Candidates did not realise that the hydration of ethene requires a catalyst.

Question 39

Response **C**. Candidates knew the monomer but did not realise that the polymer was named poly(ethene), even though it is saturated.

CHEMISTRY

Paper 0971/32
Theory (Core)

Key messages

- It is important that candidates read questions carefully in order to understand what exactly is being asked.
- Better performing candidates write precisely using the correct chemical terminology.
- Some candidates need more practice in revising specific terms which appear in the syllabus and in answering questions involving qualitative tests.
- Interpretation of data from tables and graphs and simple calculations were 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; a few candidates gained very high marks. Many candidates answered every part of each question. The exception was in **Question 2(d)(i)** where a significant number of candidates did not respond to the question, which required them to draw a circle around the carboxylic acid functional group. The standard of English was generally good.

Some candidates needed more practice in reading and interpreting questions. The rubric was misinterpreted or ignored by a significant number of candidates in a few questions. For example, in **Question 1(a)(iv)** many candidates did not heed the word 'only' in the stem of the question. In **Question 1(b)(ii)**, some candidates only wrote about the motion of the particles or the degree of separation but not both. In **Question 2(d)(ii)**, some candidates overlooked the words *type of atoms* and counted up the total number of atoms in the molecule. In **Question 7(a)(i)**, a significant number of candidates misread the question and wrote the names (anode and cathode) for the electrodes instead of the products at these electrodes. In **Question 7(d)(i)**, many candidates seemed to think that the question was about transition elements rather than metals in general. Others attempted to write chemical (symbol) equations instead of the word equations requested. Candidates should be advised that a word equation does not include chemical symbols and *vice versa*.

Some candidates needed practice in answering questions relating to qualitative analysis. For example, many did not know the test for halide ions in **Question 5(c)(ii)**. Others needed more practice in learning precise definitions. For example, many did not write a suitable definition of a homologous series in **Question 2(b)(i)** or write a full enough description of thermal decomposition in **Question 3(b)(i)**. Others were imprecise when writing the names of chemical compounds. For example, chlorine and chloride were muddled in **Questions 5(b)(i)**, **5(b)(ii)** and **7(b)** and the correct name of ammonium chloride was rarely given in **Question 6(d)**. Imprecise answers were also given in all parts of **Question 6(b)** about nitrogen oxides. Some candidates used chemical terms incorrectly. For example, in **Question 3(a)(iv)** some candidates referred to time instead of rate. In **Question 7(d)(ii)**, a large number of candidates referred to rusting even though there was no iron present.

Many candidates were able to extract information from tables and graphs and balanced symbol equations correctly. Most candidates were able to undertake simple calculations involving relative formula mass and calculations involving simple proportion. Others needed to revise these areas.

Questions involving general chemistry including atomic and molecular structure were tackled well by many candidates. Others needed more practice in explaining chemical processes especially distillation (**Question 2(e)**) and diffusion (**Question 6(a)(ii)**). Many candidates also needed to revise the uses of compounds and isotopes (**Questions 3(b)(ii)** and **4(a)(ii)**). Others needed more practice in the identification of functional groups (**Question 2(d)(i)**).

Comments on specific questions

Question 1

This question was generally well answered. Most candidates identified at least three of the substances correctly in **(a).** Part **(a)(ii)** (test for sulfur dioxide) was the least well done. In **(a)(iv)**, many candidates did not heed the word 'only' in the question and so did not gain credit. Part **(b)(i)** (changes of state) was answered well by most candidates. Others did not answer the question about the separation and motion of particles in **(b)(ii)** fully enough or suggested that the particles in liquids are well separated.

(a) (i) Most candidates identified octane. The commonest errors were to suggest either aqueous copper(II) sulfate or ethanol.

(ii) This was the least well done part of **(a)**. A minority of the candidates chose the correct answer, potassium manganate(VII). The commonest errors were to suggest either hydrochloric acid or aqueous copper(II) sulfate.

(iii) Many candidates realised hydrochloric acid turns blue litmus red. The commonest error was sodium chloride. A considerable minority chose aqueous copper(II) sulfate.

(iv) Some candidates identified water as the reactant. Others ignored the word 'only' in the stem of the question and suggested hydrochloric acid or one of the other aqueous solutions.

(v) Most candidates identified alcohol as the product of the reaction between ethene and steam. The commonest error was to choose hexane, perhaps because it was another alkene.

(b) (i) Most candidates identified freezing and condensation as the changes of state. The commonest error was to suggest sublimation in place of either freezing or condensation. A few candidates chose heating as an incorrect alternative to freezing.

(ii) The separation of the particles in liquid mercury was the least well known aspect of this question. Many candidates suggested that the particles were 'apart from each other' or 'not touching'. A significant number of candidates did not give an answer to the separation of the particles in the gas. A significant minority of the candidates did not respond to the instruction to write about both motion and separation and only wrote about one of these.

Question 2

Some candidates answered this question well and most were able to manipulate the data in the table in **(a)(i)**, balance the equation in **(b)(i)** and draw a suitable dot-and-cross diagram in (**b)(iii)**. Few candidates gave a suitable definition of a homologous series in **(b)(ii)** or recognised that helium is unreactive in **(c)**. Some candidates needed further practice in identifying the group responsible for decolourising aqueous bromine (**(d)(i)**)**.** Many candidates needed to revise the requirements and conditions needed for fermentation as well as to distinguish between fermentation and the addition of steam to ethene (**(e)**).

(a) Nearly all candidates were able to deduce the percentage of carbon dioxide correctly. The commonest errors were either to give the sum of the substances other than carbon dioxide or to round up the value to 27.

(b) (i) Many candidates were able to balance the equation correctly. The commonest error was to give $2H_2$.

(ii) Few candidates were able to interpret the term *homologous series*. Few mentioned the same functional group and many wrote imprecisely e.g. 'the properties are similar', rather than the chemical properties are similar. It is important that candidates distinguish between the words 'same' and 'similar'. Many candidates wrote about 'same chemical properties' or 'similar functional groups'. Others wrote imprecisely about general formula e.g. 'it has a general formula', rather than the same general formula.

(iii) Many candidates were able to draw a correct dot-and-cross diagram for methane. The commonest errors were to put only one electron in the overlap area; to put extra electrons on the hydrogen atoms; to omit one or two of the bonding pairs of electrons.

(c) Some recognised that helium is unreactive. A majority of the candidates did gain credit because they thought that helium is less dense than hydrogen or 'makes the balloon go higher in the air'.

(d) (i) Few candidates recognised that the C=C bond is responsible for the reactivity with aqueous bromine. The commonest errors were to ring the S=O bond, to include hydrogen atoms attached to the C=C bond (H–C=C–H) or to ring large sections of the molecule to include single bonds and double bonds. A significant number of candidates did not respond to this question.

(ii) Many candidates gave the correct number of distinct types of atom; others forgot the sulfur atom or counted the total number of atoms (19). The answers two and five were often seen as other common errors.

(e) Some candidates knew about the process of fermentation and wrote about yeast, glucose and anaerobic conditions rather than the fractional distillation of ethanol. A large number of candidates wrote vaguely about distillation and some referred to petroleum and ethene. Many gained credit for an understanding of different boiling points. Many also wrote about different melting points. Others gained credit for mention of a condenser and heating the distillation flask.

Question 3

Many candidates performed well in **(a)(i)** (handling information from a graph), **(a)(iii)** (calculation) and **(a)(iv)** (rate of reaction). Others made basic errors in deducing where the rate is greatest (**(a)(ii)**) and in explaining the term *thermal decomposition* (**(b)(i)**). Most candidates needed more practice in learning specific uses of substances (**(b)(ii)**).

(a) (i) Most candidates correctly deduced the time to collect 30 cm^3 of carbon dioxide. The commonest errors were either near misses e.g. 21 s or a factor of 10 difference e.g. 30 or 32 s.

(ii) Many candidates who chose point **P** gave vague explanations referring to more volume of gas or less time, rather than referring to the gradient of the graph. A significant number of candidates suggested an answer 'between points **P** and **Q**'. A significant number of candidates chose points **Q** or **S** and referred to the curve of the graph being greater.

(iii) A majority of the candidates did the simple calculation correctly using simple proportion. The commonest incorrect answers were 49 and 2.36 due to incorrect multiplication or incorrect use of the simple proportion method. Other candidates tried to do moles calculations. Candidates should recognise that mole calculations are not required on the Core syllabus.

(iv) Most candidates realised that increasing the temperature increases the rate of reaction. Fewer realised that using larger pieces of calcium carbonate would lead to a slower rate of reaction. Although an explanation was not required, many candidates incorrectly stated that large particles have a larger surface area. Others did not gain credit because they wrote about time taken for the reaction or volume of gas given off instead of rate of reaction.

(b) (i) Most candidates recognised that thermal means heat. Fewer candidates gave the meaning of the term *decomposition* and just reiterated this word in their answers. Others gave vague answers just referring to 'reactants forming more than one product' rather than a single reactant breaking down (into two or more products).

(ii) This was the least well done part of this question. Many candidates repeated the use given in the question and suggested making calcium oxide. A common incorrect answer was to refer to drinks or vinegar. Energy, fuels and catalyst were other incorrect answers frequently seen. Others just gave the name of a rock 'limestone' or 'chalk' (often blackboard chalk).

(iii) Many candidates did not realise that calcium oxide is basic and so gave answers other than neutralisation e.g. 'decomposition', 'addition'. Others suggested exothermic or endothermic.

Question 4

This was the best answered question on the paper. Most candidates could deduce the correct number of at least two of the sub-atomic particles in **(a)(i)** and draw the electronic structure of calcium in **(b)**. Many candidates needed to revise the uses of radioactive isotopes in industry (**(a)(ii)**). Most candidates were able to apply data from a table to deduce the order of reactivity of the elements in **(c)**.

(a) (i) Many candidates gained full credit for the correct number of sub-atomic particles. The commonest errors were to suggest 24 electrons and 20 neutrons or to give the mass number as the number of electrons or neutrons.

(ii) A minority of the candidates knew an industrial use of radioactive isotopes. Many candidates did not heed the word 'industrial' in the stem of the question and gave medical uses. Others gave uses which could not be regarded as industrial e.g. carbon–12 dating or gave vague answers such as 'making machines work'.

(b) Many candidates drew the correct electronic structure of a calcium atom. Typical errors were to draw too few inner electron shells; inner electrons shells as 2,4,8 or 4,4,8 or one or eight electrons in the outer shell.

(c) Most candidates gave the correct order of reactivity. The commonest errors were to reverse the reactivity of iron and samarium or copper and iron. Very few candidates gave a completely incorrect order of reactivity.

Question 5

Many candidates were able to extract and use information from the table (**(a)**) and to calculate relative molecular mass (**(d)**). A considerable number of candidates were also able to comment on trends correctly (**(a)(ii)**) as well as giving a suitable use for chlorine (**(a)(iv)**). In **(b)(i)** and **(b)(ii)**, some candidates needed to revise the naming of chemical compounds e.g. halogens and halides with special reference to distinguishing between iodine and iodide. Others needed more practice in learning tests related to qualitative analysis e.g. tests to distinguish halides (**(c)(i)** and **(c)(ii)**).

(a) (i) Most candidates were able to deduce the boiling point of chlorine and the density of iodine from the table of data provided. The commonest errors were to suggest that the boiling point of chlorine is below its melting point or above 59 °C or to give too low a value for the density of iodine. A few candidates gave values which were not credible from the data provided e.g. negative density.

(ii) Most candidates realised that the melting points increase down the group. Others wrote vague statements such as 'bromine and iodine have higher boiling points' rather than focusing on the trend in the group as a whole.

(iii) Some candidates realised that bromine is a solid at –20 °C. Others needed more practice at dealing with negative numbers. This was shown by the large number of candidates who suggested that bromine is a liquid at this temperature.

(iv) Most candidates deduced the colour of fluorine correctly. The commonest error was to suggest dark green; a few suggested purple.

(b) (i) Many candidates completed at least one of the boxes correctly. Common errors included potassium salt (instead of potassium iodide or potassium chloride); potassium compound; potassium (unqualified); iodine chloride. Potassium chloride was most commonly suggested, even when the candidate stated potassium iodine for the other reactant. A significant number of candidates wrote potassium hydroxide in place of potassium iodide.

(ii) The best answers stated that fluorine is more reactive than chlorine. Common errors included reference to chloride or fluoride or the reactivity of potassium. Many thought that chlorine was more reactive than fluorine. Others just referred to the position of chlorine and fluorine in the Periodic Table rather than their reactivity.

(iii) Many candidates gave a correct use of chlorine, generally associated with water treatment or swimming pools. Answers which did not gain credit were often too vague e.g. cleaning water.

(c) (i) Very few candidates realised that hydrochloric acid contains chloride ions. The best answers stated that hydrochloric acid contains chloride ions which would give a 'false' precipitate or react with the silver nitrate. Others wrote inaccurately about chlorine ions rather than chloride ions. Many candidates gave answers which were not specific enough e.g. the hydrochloric acid is reactive (without saying what it reacts with). Others wrote about it being not reactive enough or not as reactive as nitric acid.

(ii) The best answers referred to both the colours and to the precipitates. Many candidates knew that a white colour is formed when silver nitrate is added to a solution containing chloride ions. Fewer wrote the word precipitate; some just wrote the colour and others wrote 'white solution'. The colour of the precipitate with iodide ions was less well known, often being given as cream. A significant number of candidates chose colours such as blue or green or gave names of chemicals e.g. chlorine or bromine (even though there are no bromide ions present).

(d) Many candidates calculated the relative molecular mass correctly. The commonest incorrect answer was 676.5, obtained by multiplying 17 by 35.5 for the chlorine with subsequent addition. Others were able to correctly multiply one of the atomic masses by the number of atoms. A few candidates used atomic numbers instead of relative atomic masses.

Question 6

The pH of aqueous ammonia in **(a)(i)** was generally well known and many candidates could balance the equation in **(b)(i)**. Many candidates could explain some aspects of diffusion in **(a)(ii)** and the meaning of the term exothermic in **(b)(ii)**. Fewer could explain how the equation in **(b)(iii)** shows oxidation of nitrogen or in **(b)(iv)** the relationship between acidic oxides and the position of an element in the Periodic Table. Other candidates needed more practice in naming compounds (**(d)**).

(a) (i) Most candidates identified pH as being an alkaline pH. The commonest error was to suggest a pH of 7.

(ii) Some candidates recognised that evaporation and diffusion was occurring. Very few candidates wrote about the particles escaping from the liquid to form a vapour. Fewer explained diffusion in terms of the particles moving randomly from areas of higher concentration to areas of lower concentration. Many just described the smell moving or the ammonia moving. A minority of the candidates did not recognise the physical process of diffusion and described a chemical reaction between ammonia and air. The best answers included the word diffusion and the idea of particles moving randomly from higher to lower concentrations. A significant number of candidates suggested that the bulk movement of particles was from low to high concentrations.

(b) (i) Most candidates balanced the equation correctly. The commonest error was to balance with 2NO instead of 4NO.

(ii) Many candidates realised that energy is released in an exothermic reaction, but fewer focused on the nature of the energy transferred (thermal or heat). A significant minority suggested that heat was absorbed. Others mentioned the energy of the reactants or products without making any comparison. A minority of the candidates wrote about reactivity or other aspects of the reaction rather than considering the energetics.

(iii) The best answers stated that the NO gained oxygen. Others wrote too vaguely about the reaction e.g. 'NO has one oxygen and the NO_2 has 2'. Such statements are not given credit because they just state what is already shown in the equation. Some candidates wrote about electron loss, but candidates should be advised that they have to be specific if this is to be credited. For example, 'the NO gains electrons' is not sufficient because it is not clear which atom is gaining the electrons. For the Core Paper, candidates should be advised not to give their answers in terms of electrons.

(iv) A majority of the candidates suggested, incorrectly, that nitrogen dioxide is a basic oxide. The best answers referred to nitrogen dioxide being an acidic oxide because the nitrogen is a non-metal and non-metal oxides are acidic. Some candidates suggested that it was the oxygen that caused the nitrogen dioxide to be acidic (or, incorrectly, basic).

(c) Many candidates gave a suitable effect of nitrogen dioxide on health but a significant minority gave other effects such as acid rain or 'it has a low pH'. A wide range of incorrect or vague answers were seen including cancer; causes diseases; harmful to brain (confusion with the effect of lead compounds); poisons you or stops oxygen being carried in the blood (confusion with the effect of carbon monoxide).

(d) A minority of the candidates identified the salt as ammonium nitrate. Common errors were ammonia nitrate, ammonium (unqualified) or nitrate (unqualified). A significant minority of the candidates chose ions or molecules which derive neither from ammonia, nor from nitric acid e.g. ammonium sulfate or iodine. Others suggested made up compounds such as 'ammonia nitrate oxide'.

Question 7

This was one of the least well answered questions on the paper. Parts **(a)(ii)** (observations at an electrode) and **(c)** (making hydrated zinc sulfate) were answered well by only a minority of the candidates. In **(d)(ii)**, many candidates did not give comparative answers or wrote about rusting rather than the more general term corrosion. Some candidates could identify the correct electrode products in **(a)(i)**. Others made simple errors or gave answers which suggested they had not read the stem of the question well enough. The best answered parts were **(b)** (completing a word equation) and **(d)(i)** (describing the physical properties of metals).

(a) (i) Some candidates deduced both electrode products correctly. Others gave the correct products but at the reverse electrodes. The commonest errors were oxygen at the negative electrode instead of hydrogen; hydrochloric acid at the positive electrode instead of chlorine. Many candidates gave the ions at the electrodes instead of the molecules, especially chloride at the anode. A considerable minority of the candidates misread the question and gave the answers anode and cathode rather than the electrode products.

(ii) A minority of the candidates gave a correct observation such as bubbles or effervescence. A few gave incorrect observations 'anode goes green' (presumably because of the colour of chlorine) being not uncommon. Others gave the names of substances e.g. chlorine gas or hydrogen gas rather than observations. A small number of candidates wrote about electron loss or gain.

(b) Many candidates identified both zinc chloride and hydrogen correctly. The commonest error was to suggest water instead of hydrogen. Others suggested zinc hydrochloric acid instead of zinc chloride.

(c) A minority of the candidates gained full credit. The commonest errors were to invert either **A** and **E** or **D** and **F**. Many of the candidates who did not gain credit appeared to guess the order and put step **F** or **D** at the beginning.

(d) (i) Many candidates identified two physical properties that are characteristic of most metals, but few identified three distinct properties. Many candidates thought that the question was about transition elements and gave properties such as high density and coloured compounds. Others suggested hardness or strength. These were not accepted because the candidates are expected to know that Group I metals are soft and have low densities.

(ii) The best answers were given by candidates who suggested that alloys are harder, stronger or more resistant to corrosion. Many candidates did not write comparative answers and just suggested 'strong' or 'hard', which could refer to either copper or the alloy. A majority of the candidates did not gain credit for increased resistance to corrosion because they wrote about rusting, which is specific to iron. Others wrote about physical properties of which they did not have any comparative knowledge e.g. 'electrical conductivity' or 'do not apply to all metals e.g. magnetism'.

CHEMISTRY

Paper 0971/42
Theory (Extended)

Key messages

Candidates must read the questions carefully to ensure that the answer they give addresses what has been asked. This was true of **Question 1**, which required responses only from within the first 36 elements of the Periodic Table.

When a chemical equation is asked for, this means a balanced symbol equation using correct symbols/formulae and not a word equation. Word equations were frequently seen in **Questions 2(f)**, **3(a)(ii)**, **3(b)(iii)** and **5(a)(ii)**.

Candidates who performed less well had not learnt the definitions and statements within in the syllabus. This was seen in **Question 2(a)**, which asked for the percentage of clean, dry air which is nitrogen; **Question 2(g)(iii)**, which asked for the two ways of hydrolysing complex carbohydrates into simple sugars and **Question 3(b)(i)**, which asked for the meaning of the term *base*.

General comments

There were some excellent responses. Most candidates appeared to be well prepared for this paper, with only a very small proportion who may have been better advised to sit the Core paper.

There were few blank spaces. The fuel cell and the catalytic convertor were often not well known.

Far fewer candidates gave multiple responses, as very few lists were seen. Most candidates attempted to show full working in the two calculation questions, which is a good examination practice.

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

Very few candidates felt the need to write on extra pages. If extra pages are used, the questions must be clearly numbered.

Comments on specific questions

Question 1

This was based upon various parts of the syllabus and required a knowledge of the chemistry of the first 36 elements.

(a) (i) to (vii)

In general, candidates performed well. Common errors, presumably caused by mixing up mass number with atomic number, were **(i)** beryllium; **(iii)** sodium and **(iv)** oxygen.

Other frequent errors, presumably caused by candidates not appreciating that the data given referred to ions (not atoms) of an element were **(v)** argon and **(vi)** neon.

(b)(i) Francium was a very common error caused by candidates not appreciating that it was the first 36 elements only that were being asked about.

(ii) Candidates knew that calcium reacts with air to form lime.

(c) (i) It was quite well known that hydrogen was the fuel used in a fuel cell.

(ii) Very few candidates were aware that the behaviour of hydrogen within a fuel cell was equivalent to the combustion of hydrogen. Instead, many gave attempts at ionic half-equations which had hydrogen as a product.

Question 2

This was based around upon the 'Air' section of the syllabus.

(a) Most knew that 78 per cent of clean, dry air was nitrogen. Many gave the answer as 79 per cent, presumably subtracting oxygen's 21 per cent from 100 per cent and ignoring the presence of noble gases.

Weaker responses included incorrect percentage composition calculations.

(b) Most candidates knew separation of oxygen was achieved by fractional distillation of liquid air.

(c) Most candidates knew that the major adverse effect of SO_2 was acid rain.

(d) Many candidates realised that combustion of atmospheric nitrogen within a car engine released oxides of nitrogen into the atmosphere. Often responses did not mention that it was the extreme heat of the engine that allowed this combustion to happen.

Weaker responses assumed, erroneously, that nitrogen was in the fuel used.

(e) Many candidates knew that a catalytic converter changed CO and NO into carbon dioxide; few realised that nitrogen was the other harmless product. Nitrogen dioxide was frequently seen. The the identity of the catalyst was not well known; platinum, and either rhodium or palladium were accepted. Iron or nickel were the most common of the frequent incorrect responses.

(f) Some very good chemical equations were seen. One common error was to have hydrogen instead of water as the other product. Some candidates incorrectly wrote word equations.

(g) (i) Both scientific terms were well known.

(ii) The structure of the complex carbohydrate formed from three units of glucose was generally well known, with correct linkages frequently seen. Some candidates did not show continuation bonds.

(iii) In general, the two ways of breaking complex carbohydrates into simple sugars were not known.

(iv) Chromatography was frequently seen.

Question 3

This was based around the chemistry of ammonia.

(a) (i) The symbol for a reversible reaction was almost universally known.

(ii) Some very good answers were seen and it was not uncommon to award all five marks. The essential conditions for the Haber process were generally well known; occasionally units were missing. A significant proportion of candidates did not gain credit for the chemical equation. Weaker responses gave a word equation and occasionally 'N' was seen as the (incorrect) formula of nitrogen. The chemical equation was also omitted completely in some cases This was frequently the case where candidates had produced longer, unfocused answers.

Better responses were concise and stated '450°C; 200 atmospheres pressure; iron catalyst. $N_2 + 3H_2 \rightarrow 2NH_3$' and gained full credit.

(iii) The source of hydrogen used in the Haber process was well known.

(b) (i) The meaning of the term *base* was well known by many candidates.

(ii) Most candidates knew that the Contact process is used to manufacture sulfuric acid.

(iii) The chemical equation for the reaction between ammonia and sulfuric acid is challenging and relatively few candidates gained full credit. Errors included introducing water as a second product, despite no oxygen being present in the reactants. Others felt hydrogen was a second product. Many wrote the correct formula for ammonium sulfate but did not balance the equation.

(c) (i) Very few candidates could identify the green precipitate as iron(II) hydroxide.

(ii) Very few candidates identified the green precipitate; the majority knew that atmospheric oxidation converted an iron(II) compound to an iron(III) compound.

(iii) Most candidates knew the green precipitate remained when excess aqueous ammonia was added to it. Some weaker responses gave contradictory descriptions, such as 'it dissolves and remains'.

(d) (i) This unstructured calculation involving molar gas volumes was done very well. A variety of correct methods were seen.

(ii) Error carried forward could often be applied if candidates showed their working clearly. Some candidates correctly used the equations coefficients. The most frequent error was to omit the division by four to calculate the energy change when one mole of NH_3 reacts.

Question 4

This was based upon electrochemistry.

(a) Frequently the *type* of particle, i.e. 'ions', was given as being responsible for the passage of electricity in molten copper(II) bromide rather than the identity of the actual ions present.

(b) (i) Although incorrect, 'graphite' was the most frequent answer seen, presumably as a result of candidates not reading that the name of a **metal** was required.

(ii) Most candidates knew chlorine was formed at the positive electrode.

(iii) The majority of candidates realised that H^+ ions receive electrons. Better responses went on to balance the ionic half-equation but the correct state symbols were often incorrect.

(iv) Better responses stated that the pH (which is a number) *increased* and went on to explain this was because an excess of hydroxide ions remained in solution (usually expressed as 'sodium hydroxide forms'). These then went on to relate the presence of hydroxide ions causing solutions to become alkaline.

(c) (i) Candidates found this seemingly straightforward question challenging. The error of showing electrons travelling from copper to zinc was frequently seen; weaker responses often showed electrons in the solution.

(ii) This question was well answered in general. Some responses stated 'iron is less reactive', which was too vague for credit to be awarded. The name of the element (zinc or copper), which is less reactive than iron was required.

(iii) Vague responses were common and did not gain credit. It was expected that candidates would write that silver is less reactive than copper.

Question 5

This was based upon organic chemistry.

(a) (i) Better responses knew that ultra-violet light was the essential condition.

(ii) Candidates found the chemical equation for the reaction challenging.

(iii) Better responses knew this was a substitution reaction.

(iv) The completion of this equation was almost universally correct.

(b) The majority of the candidates performed well in this question. The frequent error was the omission of the non-bonding electrons on oxygen.

(c) (i) The majority of candidates knew the name of the ester formed was methyl propanoate.

(ii) Most candidates knew water was formed alongside the ester.

(iii) Many candidates did not read the question correctly. They were asked to draw the structure of an *ester*, which is an *isome*r of methyl propanoate.

The most frequent error seen was to draw the structure of methyl propanoate rather than one of its isomers. As this had a molecular formula of $C_4H_8O_2$ and an ester link, two marks could be awarded. The next most common error was to draw chemically correct structures of $C_4H_8O_2$, which did not have an ester link, e.g. butanoic acid or 2-hydroxy butanal. As these were isomers of methyl propanoate, they also could be awarded two marks.

Weaker responses had structures with pentavalent C atoms, trivalent O atoms and divalent H atoms.

(iv) 'Catalyst' was often seen. Many different temperatures and pressures were also given.

CHEMISTRY

Paper 0971/52
Practical

Key messages

- Candidates should have practical experience of doing a flame test.
- Candidates should go through their plans when answering **Question 3** before writing their response, as extra sentences were often inserted to cover missing points realised later.
- 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 can not be awarded.
- Candidates should be aware that the mark allocation reflects the number of valid points to be made for parts of questions.

General comments

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

Examiners use Supervisors' results to check comparability in **Questions 1** and **2**. The results obtained by some Supervisors and candidates in **Question 1** suggested that some centres did not use the materials specified in the Confidential Instructions.

Comments on specific questions

Question 1

(a) and **(b)**
All candidates completed the tables of results. Expected results were obtained by the majority of candidates, with temperatures rising in Experiment 1 and decreasing in Experiment 2 and generally agreeing well with those obtained by the Supervisors. A significant number of centres obtained results with the temperatures increasing in Experiment 2.

(c) Most candidates plotted all points correctly; choosing an appropriate scale on the vertical axis of the graph caused some candidates problems. A common error was to start the temperature axis at 0 °C, meaning that the plotted points covered less than half of the *y*-axis. Most curves were good attempts and best-fit straight lines drawn with a ruler scored credit when appropriate. Some candidates joined the points dot to dot with a ruler.

(d) (i) Many answers were given without following the instruction to show clearly on the grid how they were deduced.

(ii) Many candidates did not clearly extrapolate their graph and did not show where they had read their answer from the grid. Some candidates misread their scale on the *y*-axis.

(e) Generally correctly answered with an explanation given in terms of the temperature change.

(f) The suggested improvements were often irrelevant to this experiment, such as starting at a common temperature, using the same mass of solid N and O or using a stirring rod instead of a stirring thermometer. Vague answers discussed using a stop-watch instead of a stop-clock or dipping the thermometer in a constant position in the conical flask, or using a different sized flask.

Better performing candidates repeated the experiments and found the average/mean of the readings or used insulation to reduce heat losses. Using a burette or a pipette instead of a measuring cylinder to measure the volume of water would also be more accurate.

(g) Better responses explained that the temperature rise would be greater or faster as there was a lower volume of water present. Many candidates thought that the temperature rise would be lower or that the solids would not be able to dissolve.

Question 2

Solid **P** was copper(II) nitrate.

Solid **Q** was potassium bromide.

tests on solid P

(a) Most candidates correctly stated that the flame colour was green-blue or blue. References to green only or yellow were not accepted.

(b) (i) The majority of candidates reported the formation of a blue precipitate.

(ii) The blue precipitate was insoluble in excess aqueous sodium hydroxide.

(c)(i)(ii) The majority of candidates reported the formation of a blue precipitate, which dissolved in excess aqueous ammonia to form a deep blue solution. Some confused answers referred to the blue precipitate dissolving to form a deep blue precipitate, while other missed the initial formation of the blue precipitate.

(d) Better performing candidates recorded three different observations. References to the litmus turning blue and a pungent smell were most common. Stating that ammonia was present did not score credit, as this statement is not an observation.

Effervescence was often missed and the formation of a black solid was rarely mentioned.

The formation of a white precipitate was often described. References to cloudy or solid formation were ignored.

(e) Most candidates identified the presence of copper ions; a number stated that sulfate ions were present despite a positive test for nitrate ions in **(d)**. A number concluded that bromide ions were present.

tests on solid Q

(f) Many candidates recorded a red or yellow flame colouration, despite a lilac flame being the expected result. Some candidates had clearly not experienced a flame test and discussed lighted and glowing splints.

(g) The formation of a cream precipitate was given by some candidates. A significant number omitted precipitate and merely wrote a colour. Many other candidates incorrectly described the formation of a white or yellow precipitate. This showed a lack of practical expertise and experience when carrying out the halide test.

(h) Many candidates correctly identified both ions present in solid **Q**. There was some confusion between potassium and sodium. Other candidates confused bromine and bromide.

Question 3

The complete range of marks was seen in this planning question.

Some candidates did not read the information in the stem of the question and spent some time either experimenting with the individual substances in the mixture or preparing the mixture, even though the mixture was provided.

The information in the table showed how the substances reacted with nitric acid. Despite this, a number of candidates used water or other acids to separate the mixture.

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

Better performing candidates included the following in their plans:

adding dilute nitric acid to the mixture
in a suitable named container – beaker, flask or test-tube
stir or shake the mixture
until reaction stops/excess acid
filter
wash residue/polystyrene beads with water
dry residue/polystyrene beads.

A significant number of candidates showed a lack of knowledge and understanding and described how the polystyrene beads could be obtained by crystallisation of the polystyrene beads from a saturated solution of the filtrate.

CHEMISTRY

Paper 0971/62
Alternative to Practical

Key messages

Candidates should use a sharp pencil for clearly plotting points and for drawing their lines of best fit on their graphs. This allows them to correct any errors. The question might require the line of best fit to be a curve or a straight line, as appropriate. Straight lines should be drawn with a ruler, but rulers should not be used to join the points on a curve. Lines of best fit should avoid anomalous points.

Candidates should be aware that the mark allocation reflects the number of valid points to be made for parts of questions.

Candidates should go through their plans when answering **Question 4** before writing their response, as extra sentences were often inserted to cover missing points realised later.

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

General comments

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

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

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

Comments on specific questions

Question 1

(a) A number of candidates named pipette and burette the wrong way round. A significant number of candidates incorrectly named the pipette as a dropper or teat pipette.

(b) Most candidates named methyl orange or phenolphthalein. Universal indicator was widely quoted and this is not a suitable indicator for a titration. Colour changes were often the wrong way around. Orange to red was a common incorrect colour change for methyl orange.

(c) Most candidates stated ‘the volume of sulfuric acid used’. Only a minority realised that the initial and final readings of the acid in the burette should be recorded. A minority of candidates showed a lack of understanding referring to the ‘drops of acid’.

(d) Good answers showed an understanding that there would be no effect on the titration values as the amount of sodium hydroxide added to the flask would still be the same. Common wrong answers were concerned with the dilution effect of the water.

Question 2

(a) and (b)
Almost all candidates correctly completed the tables of results from the thermometer diagrams.

(c) Most candidates plotted all points correctly. Most curves were good attempts and dot to dot straight lines drawn with a ruler were rare. Some candidates drew a best-fit straight-line when a smooth curve was the obvious choice. The graphs were often not labelled.

(d) (i) Many candidates clearly indicated on their graph and showed clearly where they had read their answer from the grid at 18 °C. Some candidates misread their scale on the *y*-axis.

(ii) Generally, this was correctly answered. Some candidates did not extrapolate the graph and others misread the scale on the *y*-axis.

(e) Experiment 2 was identified as an endothermic change as the temperature decreased. A minority gave no explanation or thought it was exothermic.

(f) Often the suggested improvements were irrelevant to this experiment, such as starting at a common temperature; using the same mass of solid N and O or using a stirring rod instead of a stirring thermometer.

Better responses repeated the experiments and found the average/mean of the readings, or used insulation to reduce heat losses. Using a burette or a pipette instead of a measuring cylinder to measure the volume of water would also be more accurate.

Question 3

(a) The majority of candidates correctly stated that the flame colouration would be blue-green or blue. Incorrect references to green and yellow were common. Some candidates thought a flame test was a test for hydrogen or oxygen.

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

(c) (i)(ii) The majority of candidates reported the formation of a blue precipitate, which dissolved in excess aqueous ammonia to form a deep blue solution. Some confused answers referred to the blue precipitate dissolving to form a deep blue precipitate, while others missed the initial formation of the blue precipitate.

(d) This was well answered. The use of litmus paper turning blue was frequently given, as was a good description of a pungent smell. The formation of a white precipitate was often wrongly described.

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

Question 4

Some candidates did not read the information in the stem of the question and spent some time either experimenting with the individual substances in the mixture or preparing the mixture, even though the mixture was provided.

The information in the table showed how the substances reacted with nitric acid. Despite this, a number of candidates used water or other acids to separate the mixture.

A minority of candidates used the wrong method, such as fractional distillation or heating the mixture. These methods showed a lack of knowledge and understanding. A significant number of incorrectly described how the polystyrene beads could be obtained by crystallisation of the polystyrene beads from a saturated solution of the filtrate.

Better responses:

- added dilute nitric acid to the mixture
- used a suitable named container – beaker, flask or test-tube
- stirred or shook the mixture
- and continued until reaction stops/excess acid
- filtered
- washed residue/polystyrene beads with water
- dried residue/polystyrene beads.