CHEMISTRY

Paper 0971/11
Multiple Choice (Core)

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

General comments

Questions 11 and **26** proved to be of lower demand.

Questions 17, **25**, **27** and **32** proved to be more challenging.

Comments on specific questions

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

Question 2

Response **D** was slightly more popular than the correct one. Candidates did not appreciate that a burette is necessary to measure 0.1 cm^3 accurately.

Questions 3

This had an approximately equal number of candidates choosing each alternative. This indicates that a high proportion of candidates were guessing the answer.

Question 8

Response **B**. This was slightly more popular that the correct one. Candidates simply divided 120 by 12 rather than correctly using the information given.

Question 10

Response **C**. Nitrogen was a popular incorrect choice.

Question 13

Response **A**. More candidates chose this response than chose the correct one. They recognised the correct colour change and read no further.

Questions 17

This had an approximately equal number of candidates choosing each alternative.

Question 19

Response **A**. Candidates did not read the question properly and opted for an element in the same group.

Question 25

Response **C**. The chemistry of the blast furnace was poorly understood. Few candidates selected the correct response.

Question 27

Response **C**. This was more popular than the correct response. Candidates found the mathematics challenging and may have been unfamiliar with the experiment.

Question 29

Response **D**. This response was much more popular than the correct one. Candidates did not know that tap water contains dissolved substances and missed the term *solubl*e in option 2.

Question 32

Response **A**. This was more popular than the correct response. Candidates were not familiar with sulfur dioxide and its uses.

Questions 38

This had an approximately equal number of candidates choosing each alternative.

CHEMISTRY

Paper 0971/21
Multiple Choice (Extended)

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

General comments

Questions 4, **5**, **6**, **25**, **29**, **32**, **34** and **40** proved to be of lower demand.

Comments on specific questions

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

Question 8

Response **C**. Candidates realised from the equation that there was a difference with a factor of two. However, they applied it in the wrong direction.

Question 16

Response **C**. Candidates confused oxidising agent with the substance being oxidised.

Question 23

Response **B**. Candidates did not realise that both the elements and the compounds show catalytic activity.

Question 24

Response **D**. Candidates did not realise that copper does not react with dilute acids and missed the electrical conduction.

Question 30

Response **D**. Candidates did not realise that tap water is not pure as it contains dissolved solids, and missed the term *soluble* in option 2.

CHEMISTRY

Paper 0971/31
Theory (Core)

Key messages

- Many candidates needed more practice in questions involving qualitative analysis.
- It is important that candidates read questions carefully in order to understand what is exactly being asked.
- Many candidates needed more practice in memorising the meaning of chemical terms such as *compound* or *hydrocarbon*.
- The balancing of simple equations and extraction of data from tables was generally well done.

General comments

Many candidates tackled this paper well, showing a good knowledge of core Chemistry. Nearly all candidates were entered at the appropriate level. The standard of English was generally good. Most candidates attempted all parts of each question. The exceptions were **Questions 4(e)(i)**, **5(b)**, **5(e)**, **7(a)(i)**, **8(c)** and **8(d)** where a significant number of candidates did not respond.

Many candidates needed more practice in questions involving qualitative analysis. For example, very few candidates knew the test for an unsaturated hydrocarbon (**Question 3(c)(ii)**) or iron(II) ions (**Question 4(e)(i)**).

Some candidates needed more practice in reading and interpreting questions. The rubric was misinterpreted or ignored by some candidates. In **Question 2(b)(ii)** the words 'on health' were ignored. In **Question 4(d)**, many candidates did not refer to the equation as instructed in the stem of the question whilst in **Question 5(a)** some candidates did not choose words from the list. In **Question 6(a)** a considerable number of candidates did not write about the position of the sub-atomic particles in the atom. In **Question 6(c)** some candidates ignored the words 'medical use'.

Many candidates needed more practice in answering questions involving chemical terms without contradicting themselves. For example, in **Question 1(c)**, many candidates wrote about mixtures and in **Question 2(b)(i)** some candidates suggested that hydrocarbons were elements.

Some candidates needed more practice in answering extended questions such as **Questions 3(c)** (diffusion) and **6(a)** (position and number of sub-atomic particles).

Questions involving general chemistry, including organic chemistry, were generally tackled well by many candidates. Many candidates were able to balance simple equations and extract relevant information from tables of data. Others needed more practice in naming salts and understanding the reactions of halogens with halide ions.

Comments on specific questions

Question 1

Parts **(a)** and **(d)** were generally well answered. Many candidates identified at least three of the gases correctly in part **(a)** and gained at least one mark for the electron arrangement in **part (d)**. Fewer gave a suitable explanation for the use of helium in party balloons (**part (b)(i)**). A greater number gave a correct use of argon in **part (b)(ii)**. The definition of the term *compound* (**part (c)**) was not well known.

(a) (i) Many candidates realised that ammonia turns red litmus blue. The commonest error was to suggest sulfur dioxide.

(ii) A majority of the candidates suggested that sulfur dioxide contributes to acid rain. A wide range of incorrect answers was seen, hydrogen or methane being the commonest.

(iii) A considerable number of candidates appeared not to take account of the term *hydrocarbon* in the stem of the question and gave the incorrect answer 'carbon dioxide'. Another common error was to suggest 'argon'.

(iv) A minority of the candidates identified carbon dioxide correctly. The commonest errors were to suggest either 'hydrogen' or 'ammonia'.

(v) Many candidates identified argon as the noble gas with electronic structure 2.8.8. A wide variety of incorrect answers was seen, the commonest being carbon dioxide, hydrogen or helium.

(b) (i) A minority of the candidates gave correct answers involving the reactivity or flammability of hydrogen or the inert nature of argon. Others did not gain the mark because they implied that helium is reactive, e.g. 'helium is only slightly reactive'. Many gave answers relating to density; the majority of these suggesting that helium is less dense than hydrogen.

(ii) Many candidates suggested lights, lamps or similar correct answers. Others thought that argon was an oil, perhaps by mixing up with argan oil, or a fuel. A minority of candidates either referred to the filament in the lamp rather than the surrounding gas or gave vague statements about argon in the atmosphere.

(c) Few candidates were able to define the term *compound* with the exactitude required. Many described mixtures or unqualified combinations of atoms or sometimes just substances. Many candidates confused atoms, molecules and substances. A large number of candidates, despite referring to bonds or 'joining of different atoms', disadvantaged themselves by starting their explanation with 'a mixture of'.

(d) Many candidates scored at least one mark, most commonly for the three bonding pairs of electrons. Common errors included: extra non-bonding electrons on one or more hydrogen atoms; extra electrons on the nitrogen atom; three bonding electrons or a single non-bonding electron on the nitrogen. A small number of candidates drew a large number of electrons on a single atom, e.g. up to 12, either on each atom.

Question 2

This question was well answered in parts. In part **(a)** many candidates answered parts **(i)** to **(iv)** correctly. Few candidates worked out that the nitrogen came from the air in part **(a)(v)**. Part **(b)** was less well done with a minority of the candidates being able to give a satisfactory definition of a hydrocarbon or a suitable effect of carbon monoxide on health. Many candidates were able to balance the equation in part **(b)(iii)**.

(a) (i) A majority of the candidates gave the correct answer. The commonest errors were to give either 85.5 (the total of the other gases) or a near miss in the calculation, e.g. 15.4.

(ii) Most candidates identified hydrogen as the gas present in the lowest concentration. The commonest error was to suggest hydrocarbons.

(iii) Many candidates gave the correct elements. The commonest errors were to suggest nitrogen and carbon dioxide or carbon dioxide and water.

(iv) A significant number of candidates who gave CO_2 in part **(a)(iii)** gave the formula of nitrogen dioxide as NCO_2. Other common errors were N_2O_3 and N_2O.

(v) A minority of the candidates realised that the nitrogen came from the air / atmosphere. Many suggested that the nitrogen comes from the exhaust, the engine or from the incomplete combustion of the fuel. Others suggested that it comes from reactions involving hydrogen, carbon dioxide or water. A significant number of candidates gave answers which bore no relationship to the question, e.g. 'from industry' or 'from limestone'.

(b) (i) A minority of the candidates defined a hydrocarbon correctly. Many described mixtures of elements or combinations with other elements. Others omitted the essential idea that there were no other elements present. A significant number of candidates either suggested that hydrocarbons are elements rather than compounds.

(ii) A minority of candidates gave an answer that referred to the poisonous nature of carbon monoxide. Many suggested that it causes cancer or lung diseases or gave biological descriptions involving haemoglobin (rather than giving the effect on the body). Others gave answers that were too vague, e.g. 'effects breathing'.

(iii) Many candidates scored at least one mark for balancing the equation, usually for balancing the carbon in the carbon dioxide. The commonest examples of incorrect balancing for the water molecules were $10(H_2O)$ and $8(H_2O)$. A small number of candidates gave the incorrect balance of $2CO_2 + 2H_2O$.

Question 3

Few candidates scored well in parts **(a)(i)** (diffusion) and **(a)(ii)** (explaining why limonene is a solid at –80°C). Many candidates could define a catalyst in part **(b)(i)** and oxidation in part **(b)(ii)** but fewer were able to describe the colour change when bromine is added to an unsaturated compound in part **(c)(ii)**.

(a) (i) Many candidates recognised that diffusion was occurring. 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 limonene moving. A minority of the candidates did not recognise the physical process of diffusion and described chemical reactions with the air. Very few candidates wrote about the particles escaping from the liquid to form a vapour.

(ii) A minority of the candidates gained both marks. Those who scored one mark either did not give an explanation or gave the state as being liquid. Some responses just referred to the melting or boiling points as changing, which was insufficient. A significant number of candidates misunderstood the negative signs and wrote statements such as 'because –80°C is higher than –74°C'.

(b) (i) A majority of the candidates could describe the purpose of a catalyst. Many seemed to think that all catalysts are enzymes. Common errors were to suggest that a catalyst changes the rate of reaction and this was not a specific enough answer, or to refer to other properties of catalysts, e.g. 'they are not used up in the reaction'. Some candidates suggested incorrectly that catalysts do not take part in the reaction.

(ii) Many candidates gave a suitable definition of oxidation. Others gave more than one definition and sometimes contradicted themselves by writing incorrect statements such as 'gain of electrons' or 'when you take the oxygen away'. Some candidates referred to the oxygen alone without reference to any other element or gave vague answers such as 'when you oxidise something'.

(c) (i) Many candidates identified the double bond. The commonest errors were to either refer to the CH_3 group or to the OH group.

(ii) Some candidates knew the correct colour change when aqueous bromine reacts with an unsaturated compound. Others either reversed the colours (colourless to orange) or guessed the colour of the product, green, purple or blue being commonly seen. Common incorrect colours for aqueous bromine were red or pink. A few candidates suggested white or clear for the colour of the product, which was not accurate enough.

Question 4

Many candidates gave good answers to part **(a)**, **(c)** and **(e)(ii)**. Fewer were able to describe three ways in which the properties of iron differ from those of potassium in part **(b)** and many did not use the equation provided in part **(d)** to explain how the iron(III) oxide is reduced by hydrogen. The test for iron(II) ions in part **(e)(i)** was not well known and in part **(f)** many candidates did not use all the information in the diagram.

(a) Some candidates gave the correct order of reactivity but many reversed the order completely. Others seemed to rely on their existing knowledge of the reactivity series rather than using the information in the table. This was obvious from the large number of candidates who wrote down lists of relative reactivity either next to the question or on one of the blank pages.

(b) Many candidates gained one or two marks for correct comparisons of the properties of iron and potassium but few gained all three marks. Many described properties which were common to both metals e.g. conductivity. Some thought that one was a metal and the other was a non-metal or described their relative positions in the Periodic Table. A significant number of candidates did not mention which metal they were writing about. Many candidates did not score because they wrote about electronic structure, valency or physical state or did not compare properties sufficiently well, e.g. iron is malleable, rather than less malleable than potassium.

(c) Most candidates balanced the equation successfully. The 3(Fe) was the mark most often scored. Common errors were 4(Fe) + 2(O_2); 2(Fe) + 2(O_2) and 2(Fe) + 3(O_2).

(d) Many candidates gave a definition of reduction but did not apply the concept of reduction to the equation. Others described the equation without explaining how it was a reduction. Many candidates described the iron as losing oxygen rather than the iron oxide losing oxygen.

(e) (i) Very few candidates knew the test for iron(II) ions. A wide variety of incorrect test reagents were seen including indicators (mainly litmus), flame tests, barium nitrate and hydrochloric acid. Many described how iron chloride might be formed. A few suggested that a green precipitate would be formed but used the incorrect test reagent. Of those who gave the correct test reagent, about half suggested a red-brown precipitate.

(ii) Some candidates gave the correct molecular formula. The commonest error was to suggest $FeCl_3$. Other common errors included $FeCl_6$, 2Fe6C*l* or 2Fe + 6C*l*. Some candidates disadvantaged themselves by writing two formulae, one correct and one incorrect.

(f) Few scored more than one mark for this question. Many candidates only chose one bottle. Some candidates realised that calcium chloride dries the air but then assumed that it removed oxygen as well. Many candidates wrote conflicting statements. Some realised that air and water were necessary for rusting but were unable to identify which of the bottles contained only air, only water or both air and water.

Question 5

Most candidates gave a good answer to part **(a)** and many answered parts **(b)** and **(c)** correctly. Fewer candidates predicted the correct electrode products in part **(d)**. Even fewer identified the brown solution or gave a correct explanation in part **(e)**.

(a) Most candidates performed well. The commonest errors were: electroplating or heat, instead of break down; element, instead of compound; gaseous or electroplating, instead of molten and electroplating, instead of electricity. A few candidates did not select words from the list.

(b) Most candidates gained at least one mark. Some confused the anode with the cathode; others labelled the electrolyte incorrectly. The commonest errors being to label the electrodes or the cell.

(c) Many candidates gave a suitable reason for using a graphite electrode. Others just stated that it was a non-metal or gave irrelevant properties such as density, hardness or catalysis. A considerable minority referred to cheapness.

(d) Some candidates realised that zinc is formed at the negative electrode. Fewer identified iodine being formed at the positive electrode. Many reversed the products, having the zinc at the positive electrode. Common errors, applying indiscriminately to each electrode, included hydrogen, oxygen or zinc iodide. A significant number of candidates gave irrelevant answers such as 'electrons' and 'neutrons'.

(e) A minority of candidates gained one mark and very few gained both marks. The commonest error was to suggest that the brown colour was caused by the formation of bromine even though there was no bromine or bromide in the equation. A considerable number of candidates suggested that zinc chloride is the brown-coloured product. A few candidates recognised that chlorine is more reactive than iodine, but most made the comparison with bromine, zinc bromide or zinc. Others tried to give reasons unrelated to the reactivity series.

Question 6

Candidates responded well to some parts of this question, especially parts **(b)** and **(d).** The question about the structure of the atom (part **(a)**) was less well answered with many candidates ignoring the position of the sub-atomic particles. In part **(c)**, some candidates knew about the medical uses of radioactive isotopes; others did not take note of the word 'medical' in the stem of the question and wrote about other uses.

(a) The location of electrons was not made clear by many candidates. Statements such as 'in energy levels' or 'in shells' were not sufficient to gain the mark. Many candidates suggested that 'the electrons are outside the atom', rather than outside or surrounding the nucleus. Many gained only three marks because they identified the correct number of number of electrons, protons and neutrons but did not describe their position. Others described the position by trying to relate it to the isotopic symbol, e.g. 'the proton number is lower' or 'the neutrons plus protons are up'.

(b) Many candidates performed well. Element was nearly always seen.

Some candidates wrote 'molecular' or 'nucleon' in place of 'atomic' or 'ions' in place of 'atoms'. Others did not use words from the list as instructed.

(c) Some candidates ignored the word 'medical' in the stem of the question and described energy production or testing for leakages in pipelines. Others wrote vague statements such as 'in medicines' or incorrect statements such as 'chemotherapy'.

(d) A majority of the candidates recognised the isotope of uranium. The commonest error was to suggest the isotope of iodine. The isotope of xenon was also selected by a minority of candidates.

Question 7

Parts **(a)(i)**, **(a)(iii)**, **(b)** and **(d)** of this question were answered well by a majority of the candidates. In part **(a)(ii)** the direction of the trend was not always made clear whilst in part **(c)**, the correlation between the basic nature of sodium oxide and the position of sodium in the Periodic Table was often missing or the answers were too vague. In part **(e)** some candidates were able to complete the word equation correctly. Others gave names which appeared to be a random arrangement of elements and compounds.

(a) (i) Most candidates gave suitable figures within the ranges so that a trend was followed. More candidates made errors with the values for atomic radius than with the values for thermal conductivity.

(ii) Some candidates did not make clear whether the direction of the trend in boiling point was decreasing up or down the group. Others tried to link the trend in boiling point to the trend in atomic radius or reactivity, often unsuccessfully.

(iii) Some candidates gave answers that were identical to the observations about the extent of bubbling for potassium, e.g. 'very rapid bubbling'. Others just suggested 'bubbling' without any further qualification or suggested that there was 'no reaction'. A significant number of candidates gave a description that was not an observation such as 'reacts rapidly'.

(b) Many candidates realised that an electron is lost when a sodium atom forms a sodium ion. The commonest error was to suggest electron gain. A few candidates suggested that the sodium atom gains a proton.

(c) Many candidates realised that sodium oxide is a basic oxide but a considerable number thought that sodium oxide is an acidic oxide. The best answers focussed on the position of sodium in the Periodic Table or the fact that sodium is a metal. Common errors included: 'it is a less reactive oxide'; 'sodium gains protons' or 'sodium gains oxygen'.

(d) Many candidates calculated the relative formula mass correctly. The commonest errors were: to use atomic numbers rather than atomic masses; to use a relative atomic mass of carbon of 16, thus giving an answer of 92, or to not take the number of each atom into account, thus giving an answer of 36.

(e) A minority of the candidates gained full credit for the word equation. A common error was to suggest that hydrogen is formed instead of water. The salt was sometimes named as an incorrect combination of elements and compounds, e.g. 'sodium sulfuric oxide', 'sodium sulfuric acid'. Other common errors were 'sodium hydroxide', 'sodium sulfite' or 'sodium sulfide'.

Question 8

Some candidates gave good answers to most parts of this question but a considerable minority did not attempt parts **(c)** and **(d)**. Most candidates were able to read the volume of gas from the graph in part **(b)**. Fewer gave a convincing explanation of why the volume of hydrogen remains the same in part **(a)** or could name the salt in part **(d)**.

(a) Some candidates just paraphrased the stem of the question and wrote answers such as 'the hydrogen produced stays the same'. Others described a limit to the maximum amount of hydrogen released without further explanation. A few candidates described correctly that hydrogen chloride was the limiting reagent. Others did not take note of the term *excess zinc* in the stem of the question and suggested that all the zinc had been used up.

(b) A majority of the candidates deduced the volume of gas correctly. The commonest error was to misread the scale of the graph and give a value of 48 cm^3 instead of 38 cm^3.

(c) Many candidates gained credit for drawing a shallower gradient. Fewer gained credit for estimating the final volume of hydrogen produced when the concentration of hydrochloric acid is halved. Many drew curves which ended with the same overall volume and a significant number drew curves that ended up higher than the 54 cm^3 on the *y*-axis.

(d) Some candidates gave the correct name of the salt. Others either made up names such as zinc hydrochloric acid or added elements that were not present in either reactant, e.g. oxygen (incorrect answer: zinc oxide) or iodine (incorrect answer: zinc iodide).

(e) A majority of the candidates realised that the pH value of an acid is below pH 7. A significant number suggested pH 7. Fewer suggested values of pH 9 or pH 13.

CHEMISTRY

Paper 0971/41
Theory (Extended)

Key messages

- Candidates should be reminded to use precise terms and words where applicable. For example, there was frequent incorrect use of terms in **Question 1(a)** where it was frequently written that two atoms make a compound or in **6(b)** where it was frequently written that one element replaces a molecule.
- Candidates should be reminded that if a specified number of characteristics of a substance is asked for, such as **Questions 2(e)**, **3(a)**, **5(a)(ii)**, **5(b)** and **5(e)(iii)**, then no more than this number should appear in the answer; any incorrect characteristics given may be viewed as a contradiction to the correct responses.
- Better performing candidates had good examination techniques, such as underlining of command words in the questions. Candidates should be encouraged to read questions carefully.
- Candidates should look to make answers concise and keep to the space available. Better performing candidates made use of simple bullet points rather than long paragraphs; this was seen frequently in **Question 3(b)**.

General comments

Working should be shown in calculations and this working should be set out so that it can be followed. This will allow method marks to be awarded in calculations even if the final answer is incorrect.

When a question asks for a *chemical equation* a word equation will not be accepted. Where a *word equation* is asked for, candidates should refrain from writing a chemical equation as these are more difficult and increase the likelihood that an error will be made.

Comments on specific questions

Question 1

(a) Most candidates were able to explain the term *compound*. Candidates who performed less well showed a lack of understanding of the linking of basic terms such as *atoms*, *molecules* and *elements*.

(b) Most candidates knew this straight forward method of separation. Many omitted to attempt the dissolving stage and it was evident that a significant number of candidates assumed that evaporation and crystallisation were separate stages.

(c) (i) The name of the condenser was well known; a minority realised that cooling water needs to enter at the lower aperture only.

(ii) Most candidates included a bung in the diagram accompanied with the logical response that it prevented alcohol vapours escaping. Some candidates opted to draw a thermometer but often left substantial gaps either sides of it. The need for a thermometer was less well understood.

(iii) A minority of candidates knew that the flammability of alcohols was the reason to avoid using a Bunsen burner. Several common misconceptions, such as a lack of temperature control of the mixture or possible cracking of the flask, were seen.

(iv) Some excellent answers were seen; there were also some imprecise answers with much confusion between evaporation, boiling and melting. Such responses indicated that the candidate was not familiar with the use of a water bath and did not realise that a water bath could not be heated to the temperatures needed to boil the alcohols. A common error was to assume that the boiling points of alcohols **C** and **D** were too close together.

Question 2

(a) Most candidates were able to determine that element Z must be calcium; neon was a commonly seen error.

(b) Nearly all candidates indicated knowledge of what periods are in the Periodic Table; many mis-counted and assumed F*l* was in Period 6.

(c) Most candidates were able to use the copy of the Periodic Table provided to spot that F*l* was a Group 4 element and would have four outer shell electrons.

(d) (i) The term *radioisotopes* was not well known. The most common error was to attempt a definition of isotopes.

(ii) Most candidates answered this correctly.

(e) (i) Most candidates were able to give two physical properties that are typical of metals. Many candidates opted to give more than two properties. This was not asked for and some candidates contradicted previously correct responses.

(ii) Many candidates did not understand the difference between physical and chemical properties and gave physical properties as the answer. Better performing candidates knew that the oxide of a metal would be basic.

Question 3

(a) The correct answer, hot air, was seldom seen. Oxygen was the popular wrong answer. Many other incorrect answers were seen, ranging from iron ore to zinc blende.

(b) There were some well written, well-structured and suitably detailed answers. Many candidates clearly worked hard to learn this industrial process thoroughly. Candidates who performed less well found this process difficult to recall or difficult to sequence correctly. Candidates are advised to use a bullet point approach and to use short sentences.

(c) Carbon was well known as the main impurity of iron extracted from the blast furnace; very few stated that oxygen needs to be blown **through** molten iron and also did not realise the significance that carbon dioxide was able to escape as a gas.

Question 4

(a) Relatively few candidates realised that the definition was in fact that of relative atomic mass. ‘Mole’, ‘Avogadro’s constant’ and ‘relative molecular mass’ were popular alternatives.

(b) The origin of the different terms was not well known with most candidates not appreciating the ionic and covalent nature of the two substances. A common mistake was to focus on butane being organic and KF being a compound.

(c) Many candidates were able to calculate the correct answer to this demanding question but having arrived at a relative molecular mass value of 38, did not realise that this gas must be fluorine (F_2). Common incorrect identities included strontium and potassium.

(d) Candidates were not confident in the mathematical method to find an empirical formula. A significant proportion of candidates rounded calculated values too soon in the calculation, leading to incorrect whole number ratios of moles. Many candidates did not calculate the mass of oxygen in the compound as an initial step of the calculation, but credit could still be earned for the rest of the work provided clear working out was shown.

(e) Candidates found this question challenging. Having determined the molecular formula of the oxide or the relative formula mass of P_2O_3 or even P_4O_6, they went on to do irrelevant calculations instead of determining the relative molecular mass.

Question 5

(a) (i) The term *catalyst* was familiar to candidates as something which increased the rate of a reaction but remained unchanged at the end of the reaction. It is not strictly true that catalysts do not take any part in the reaction, the key point is that they remain unchanged at the end of the reaction. Some candidates assumed catalysts had to be enzymes.

(ii) Many candidates repeated properties given in the question such as ‘forms coloured ions’ or gave physical properties instead of a chemical property which was asked for.

(b) The physical properties given were usually correct; some candidates did not appreciate that this question referred to physical properties of transition metals, which were not shared with Group 1 metals and gave the same general physical properties of metals as already seen in **2(e)(i)**.

(c) (i) The products of this reaction were often correct but a significant number of candidates omitted state symbols or erroneously assumed $ZnSO_4$ to be (s).

(ii) This part was not well-attempted. Where candidates did realise where the activation energy arrow should go, many arrows were of the wrong length or were double-headed.

(iii) The vast majority identified the reaction as being exothermic but the reason was often inadequately stated or was flawed. One common flaw was to include comments about the energy needed for bond formation or the energy released when bonds are broken.

(d) Very few correct energy profiles for a catalysed reaction were seen.

(e) The electrolysis of aqueous copper sulfate was well known.

(i) Most candidates attempted an ionic half-equation and copper was frequently seen as the product. State symbols were often omitted.

(ii) Non-observational responses such as ‘copper is formed’ were frequently given. Candidates should be aware that observations need two parts: firstly, the colour, secondly the state of the substance. In this case, ‘pink solid’ was expected.

(iii) Better performing candidates knew that the blue colour of the solution would fade and that effervescence would also take place. Candidates should remember that a colourless gas cannot be seen so is not an observation.

(iv) Better performing candidates realised that a green gas would be seen. Non-creditworthy responses included ‘chlorine is made’, which missed out the key details of what would actually be seen.

Question 6

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

(b) Better performing candidates knew that *saturated* referred to all bonds being single. To say ‘it has single C–C bonds’ is not correct as alkenes (apart from ethene and propene) have at least 2 C–C bonds. Some candidates incorrectly wrote about saturated solutions.

(c) (i) Many candidates understood the principle of substitution but did not adequately describe the process in terms of one atom taking the place of another atom.

(ii) The need for ultraviolet light (or sunlight) was known by many candidates

(iii) It was expected that candidates would give the products of mono-substitution (C_2H_5Cl + HCl) but frequently di-substituted $C_2H_4Cl_2$ was given along with H_2, which indicated some understanding of the idea of substitution.

(d) (i) Candidates were aware of the concept of an addition reaction but did not state the key point that only one product is formed. As an alternative, the idea of the C=C double bond being broken was accepted. Imprecise answers included simple statements such as ‘because bromine is added to the molecule’ and these could not be credited.

(ii) Candidates found this a challenging question. A large number of the candidates who gave a dibromo- product attached the bromines each to C_1 and C_3 whereas others attached both bromines to the same C atom. Some drew dibromoethene.

(e) Most candidates realised that but-2-ene was the unbranched isomer required and could successfully draw and name the isomer. Some correct structures were shown which were not fully displayed.

(f) (i) Poly(ethene) was known by most of the candidates.

(ii) The completion of the equation was reasonably well attempted. Better performing candidates included continuation bonds bisecting brackets and the use of a subscript ‘n’.

(g) Most candidates were able to draw at least one amide link but very few were able to orientate both amide links in the correct alignment for the part of the protein shown.

(h) Better performing candidates recognised the ester as ethyl butanoate and consequently gave the names of the reactants as ethanol and butanoic acid. Only a small minority of candidates realised that water is also a product. Some candidates did not notice that a **word** equation was asked for.

CHEMISTRY

Paper 0971/51
Practical Test

Key messages

- In the planning question (**Question 3**) 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.
- 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, bubbles or effervescence' is an observation; 'a gas or carbon dioxide was given off' is not an observation.
- Candidates should avoid giving lists of answers, as an incorrect response can contradict a correct one. For example, if the correct answer is 'precipitate dissolves' and a candidate writes 'precipitate dissolves and a white solid forms', no mark can be awarded.

General comments

The vast majority of candidates successfully attempted all of the questions. Almost all centres were able to gain the expected results in **Question 1**, with *Experiment 5* showing a large increase in time compared to *Experiments 1–4*.

Candidates found the last question, **Question 3**, challenging.

Comments on specific questions

Question 1

(a) The table of results was often completed correctly. A common error was completing the time for *Experiment 5*, leaving the time in minutes and seconds.

(b) Most candidates plotted the points correctly but often not clearly. Poorly drawn line graphs were evident, without a smooth curve. The section between 10 cm^3 and 30 cm^3 proved challenging with some candidates drawing a straight line with a ruler. Others drew a best-fit straight line through all of the points.

(c) The formation of a yellow precipitate was the expected description of the appearance of the mixture in the flask. Vague references to milky and white were ignored.

(d) (i) Candidates should be encouraged to show clear construction lines 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.

(ii) The question asked for a calculation and marks were lost for leaving the answer as a fraction. Incorrectly rounded numbers could not be awarded credit.

(e) (i) A few candidates confused rate and time and so incorrectly stated *Experiment 5,* as it had the longest time.

(ii) Good responses referred to the presence of more particles and hence more frequent collisions between the particles. A lack of understanding was seen with many candidates suggesting that at higher concentration the particles had more energy or that more collisions released more energy.

(f) Many candidates gave a burette or pipette. Some candidates did not read the question and stated that a measuring cylinder is more accurate than a measuring cylinder.

(g) The difference to the results caused by using a smaller conical flask was only realised by better performing candidates. Many candidates thought the concentration or pressure of the reactants would increase and the rate of reaction would increase. Candidates who have done this sort of experiment should be familiar with how changing the reaction vessel will change the results obtained. In this case, a greater depth of reacting mixture would lead to the cross disappearing from view in shorter times.

(h) A common mistake was to join their sketch line to their plotted line so having decided the reaction would be slower they then showed the reaction slower most of the time but having the same rate at the highest or lowest concentration. A significant number of candidates did not follow the instruction to draw their sketch on the grid and filled the space at **(h)** with a sketch of a graph which was not comparable with the original on the previous page.

Question 2

Solution **A** was dilute nitric acid.
Solid **B** was zinc carbonate.

(a) A number of candidates recorded unexpected pH numbers greater than 7.

(b) This was generally well answered with candidates observing bubbles or effervescence.

(c) Only a minority recorded that a blue solution was formed, The formation of a black colouration/precipitate showed a lack of understanding, having just added copper(II) oxide to the solution. The mention of green solutions and blue precipitates being formed scored no credit.

(d) Marks were awarded for noticing that the solid turned yellow on heating. A significant number of candidates did not describe that the solid returned to a white colour after standing for a minute. Credit was given for recording the formation of water droplets/condensation.

(e) Candidates were required to realise that the gas produced was carbon dioxide and then give the test for carbon dioxide. Blue litmus is not an appropriate test since candidates should know that there are other acidic gases. Similarly, the use of a lighted splint is not appropriate. The fact that the splint goes out tells us that the gas does not support combustion and is not flammable – the same result is obtained with nitrogen and ammonia.

(f) (i) The expected observation was that a white precipitate formed.

(ii) The precipitate dissolving was missed by many candidates.

(g) (i) The expected observation was that a white precipitate formed.

(ii) The precipitate dissolving was missed by many candidates.

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

(i) Only the better performing candidates realised that a positive nitrate test showed the solution was nitric acid. Some candidates realised that **A** was an acid.

(j) Candidates found identifying solid **B** challenging. Calcium and ammonium compounds were frequently named. Despite the correct observations to the tests some candidates did not use the notes given on pages 11 and 12 to help identify the solid **B**.

Question 3

A significant number of candidates did not attempt the question.

There were a number of acceptable methods for determining the solubility of a salt in water. Many candidates scored credit for specifying a measured volume of water and heating it to 40°C. The commonest method was to add potassium chloride to the water until no more dissolved, filtering off the excess salt, drying the solid and weighing the residue. This mass was then subtracted from the initial mass taken. Many candidates using this method did not mention 'add the potassium chloride to the water until no more dissolves/until in excess' and could not be awarded that mark.

Variants involved heating the filtrate to dryness or weighing the beaker of water initially and then reweighing when the solution was saturated.

Credit was given for naming the apparatus used to measure the volume of water and indicating that the mixture of the potassium chloride and water should be stirred to facilitate the dissolving.

A common error was to produce a plan based on the time it took the salt to dissolve or the speed of the process rather than the mass that would dissolve. Candidates should read the question carefully as this clearly related the solubility of the salt to the mass of the salt.

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, bubbles or effervescence' is an observation; 'a gas or carbon dioxide was given off' is not.
- Candidates should avoid giving lists of answers, as an incorrect response can contradict a correct one. For example, if the correct answer is 'precipitate dissolves' and a candidate writes 'precipitate dissolves and a white solid forms', no mark can be awarded.
- In the planning question, **Question 4**, there is no need to write a list of apparatus at the start of the answer, any apparatus used should be referred to in the description of the experiment so that it is clear for what purpose that apparatus has been used.

General comments

The vast majority of candidates successfully attempted all of the questions. Candidates found the last question, **Question 4**, challenging.

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 burette. Pipette, funnel and measuring tube were common incorrect answers.

(b) Methyl orange, phenolphthalein and litmus gained credit. Universal Indicator is not suitable for use in titrations.

(c) (i) This was generally well-answered with most candidates identifying the anomalous point.

(ii) Many answers were vague referring to human error, misreading the burette or parallax errors. Credit was awarded for difficulties in judging the end point and consequent overshooting. Using too much sodium hydroxide was a high-level response.

(iii) Some candidates were able to calculate the average volume of nitric acid and give their answer to an appropriate number of decimal places.

(d) Marks were awarded for realising that less acid was used and therefore the acid was more concentrated. Confused answers were common. Descriptions of a displacement reaction showed a lack of knowledge and understanding. Some candidates stated that the nitric acid must be less concentrated as it was called 'dilute nitric acid'.

Question 2

(a) The table of results was often completed correctly. A common error was completing the volume for *Experiment 1*, suggesting candidates may not have read through the experiment details carefully. Errors were also seen recording the times for *Experiments 4* and *5* leaving the time in minutes and seconds or just recording the seconds and ignoring the minutes.

(b) Most candidates plotted the points correctly but often not clearly. Poorly drawn line graphs were evident, without a smooth curve. The section between 10 cm^3 and 30 cm^3 proved challenging, with some candidates drawing a straight line with a ruler. Others drew a curve with a point of inflection and so had the curve becoming less steep to the left rather than steeper.

(c) (i) 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.

(ii) The question asked for a calculation and marks were lost for leaving the answer as a fraction. Incorrectly rounded numbers could not be awarded credit.

(d) (i) A few candidates confused rate and time and so incorrectly stated *Experiment 5* as it had the longest time.

(ii) Good responses referred to the presence of more particles and hence more frequent collisions between the particles. A lack of understanding was seen with many candidates suggesting that at higher concentration the particles had more energy or that more collisions released more energy.

(e) Many candidates gave a burette or pipette. Some candidates did not read the question and stated that a measuring cylinder is more accurate than a measuring cylinder.

(f) The difference to the results caused by using a smaller conical flask was only realised by better performing candidates. Many candidates thought the concentration or pressure of the reactants would increase and the rate of reaction would increase. Candidates who have done this sort of experiment should be familiar with how changing the reaction vessel will change the results obtained. In this case a greater depth of reacting mixture would lead to the cross disappearing from view in shorter times.

(g) A common mistake was to join their sketch line to their plotted line so having decided the reaction would be slower they then showed the reaction slower most of the time but having the same rate at the highest or lowest concentration.

Question 3

(a) The majority correctly identified hydrogen as the gas given off in **test 2**. Responses indicated that some candidates found this challenging.

(b) Solution **A** was often identified as an acid but many did not use the result of **test 3** to identify sulfate ions.

(c) Candidates were required to realise that the gas produced was carbon dioxide and then give the test for carbon dioxide. Blue litmus is not an appropriate test since candidates should know that there are other acidic gases. Similarly the use of a lighted splint is not appropriate. The fact that the splint goes out tells us that the gas does not support combustion and is not flammable – the same result is obtained with nitrogen and ammonia.

(d) (i) The expected observation was white precipitate formed. Many responses mixed up this test with the nitrate ion test and produced ammonia despite no aluminium being added and the mixture not being heated.

(ii) The precipitate dissolving was known by most candidates.

(e) (i) The expected observation was that a white precipitate formed.

(ii) The precipitate dissolving was known by most candidates.

Question 4

There were a number of acceptable methods of determining the solubility of a salt in water. Many candidates scored credit for specifying a measured volume of water and heating it to 40°C. The commonest method was to add potassium chloride to the water until no more dissolved, filtering off the excess salt, drying the solid and weighing the residue. This mass was then subtracted from the initial mass taken.

Variants involved heating the filtrate to dryness or weighing the beaker of water initially and then reweighing when the solution was saturated.

Credit was given for naming the apparatus used to measure the volume of water and indicating that the mixture of the potassium chloride and water should be stirred to facilitate the dissolving.

A common error was to produce a plan based on the time it took the salt to dissolve or the speed of the process rather than the mass that would dissolve. Candidates should read the question carefully as this clearly related the solubility of the salt to the mass of the salt.