CHEMISTRY

Paper 0971/11
Multiple Choice (Core)

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

General comments

Candidates found this a challenging paper. Questions which required more than one piece of information, such as those laid out in two columns or as multiple completion such as **Questions 32**, **35** and **36**, proved to be most difficult.

Candidates found **Questions 2** and **24** to have the least challenge.

Questions 5, **19**, **20**, **26**, **32**, **35** and **36** were most demanding.

Comments on specific questions

Question 5

Candidates recognised that ionic compounds have high melting points; few recalled that they do not conduct electricity when solid. Option **B** was the most common incorrect answer with few candidates choosing options **C** or **D**.

Question 6

Option **B** was chosen by a third of the candidates, where they recognised the nature of covalent bonding but not the number of outer shell electrons around carbon and hydrogen atoms in methane.

Question 10

Candidates must take care when answering questions containing the word ‘not’. Few of the candidates who performed less well overall answered this question correctly. Options **C** and **D** were chosen by two thirds of these candidates.

Question 13

Candidates confused both the hydrated form and the change needed to turn it white. Option **A** was the most common incorrect answer.

Question 17

Many candidates did not recognise the significance of adding an excess of copper(II) carbonate and chose to crystallise before removing this excess solid. Option **A** was therefore the most commonly chosen response.

Question 19

The correct answer was the most commonly chosen response. Some candidates chose option **C**, confusing the trend in both melting point and density of Group I elements.

Question 20

This was a challenging question which required candidates to recall both the physical properties and the reactivity of Group VII elements. Option **A** was chosen by almost a third of the candidates.

Question 23

Candidates who performed less well overall chose option **B**.

Question 25

This question required the candidates to identify that the structure shown represents an alloy and to recall that brass is an example of an alloy. Most candidates recognised both of these; some thought that graphite was an alloy and chose option **A**.

Question 26

This question was not well answered. Most candidates recalled that graphite does not react with dilute acids but did not recall the reactivity of iron and copper. Option **B** was the most common response.

Question 32

Most recognised the characteristic C=C group of an alkene. Many candidates confused the O–H group of an alcohol for that of a carboxylic acid. Option **C** was the most commonly chosen response.

Question 35

This was a challenging question and the distribution of responses suggests that many candidates were guessing. Option **D** was a common incorrect response amongst candidates who performed less well overall.

Question 36

This was one of the most challenging questions on this paper. Overall, candidates were more likely to choose one of the distractors than the key. Candidates should be reminded that ethanoic acid will react in a similar way as mineral acids when added to metals, carbonates and metal oxides.

Question 39

Many candidates did not recognise that the dissolved salts must be separated from sea water to make it drinkable. Filtration, option **C**, was a common incorrect answer.

Question 40

Most candidates used the observation with aqueous sodium hydroxide to identify the presence of an ammonium ion. The carbonate ion test was less well recalled. Option **D** was a very common incorrect answer.

CHEMISTRY

Paper 0971/12
Multiple Choice (Core) 12

There were too few candidates for a meaningful report to be produced.

CHEMISTRY

Paper 0971/21
Multiple Choice (Extended)

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

General comments

Overall, the candidates found this to be an accessible paper.

Questions 2, **4**, **29**, **30** and **39** were of the lowest demand.

Questions 17, **31**, **36** and **38** were the most demanding questions.

Comments on specific questions

Question 5

Questions which have the word ‘not’ in the question must be read carefully. Adding a tick or cross next to each statement may help candidates to identify the correct answer. Candidates who performed less well overall appeared to be guessing.

Question 8

Many candidates recognised the 4 : 8 ratio described by the equation but did not use the relative masses of the two substances. Option **C** was the most common answer.

Question 15

Candidates who performed less well overall either confused weak and strong acids or assumed that lower pH corresponded to a weaker acid. Many of these candidates chose option **B**.

Question 17

The question was found to be quite challenging. There was evidence of guessing.

Question 21

Better performing candidates had little difficulty with this question whereas others were more likely to choose any of the other options. Option **A** was the most common incorrect answer. It is a common misconception that bromine is gaseous at room temperature and pressure.

Question 26

This question was not well answered. Most candidates recalled that graphite does not react with dilute acids but did not recall the reactivity of iron and copper. Option **B** was the most common response.

Question 28

Candidates who performed less well overall appeared to have been guessing.

Question 31

Methane contributes to the enhanced greenhouse effect by causing some of the thermal energy emitted from the Earth to be reflected back towards the Earth rather than being lost to space. This trapping of heat contributes to global warming. For this question, option **B** was the most common incorrect answer.

Question 36

Many candidates did not recall that the reaction of an alkene with bromine is an addition reaction. Option **B** was the most common answer.

Question 38

This was a challenging question. Peptide bonds are found in proteins and in nylon. To distinguish between their structures, candidates needed to determine whether the monomers would be diamines and dicarboxylic acids or amino acids. Many candidates did not make this distinction and chose option **A**. Few candidates thought that the structure showed ester linkages.

CHEMISTRY

Paper 0971/22
Multiple Choice (Extended)

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

General comments

Overall, candidates found this to be quite an accessible paper.

Questions 1, **2**, **3**, **5**, **13** and **22** had the lowest demand.

Questions 28 and **37** had the highest demand.

Comments on specific questions

Question 9

Candidates who performed less well were more likely to confuse the anode and cathode and so suggest option **C**. Some candidates chose option **B**, which would be the correct half-equation for a dilute acid or the cation of a reactive metal.

Question 10

Questions which contain the word 'not' must be read carefully. It may be helpful for candidates if they place a tick or cross next to each statement when deducing the correct answer. Option **D** was the most commonly given incorrect answer.

Question 18

Most candidates recognised the need to filter the reaction mixture. Confusion arose as to whether it was the filtrate or the residue that should be collected. Candidates who performed less well overall were much more likely to choose option **C**.

Question 26

Most candidates correctly recalled that copper does not react with dilute acids but a significant number of candidates thought that magnesium would react violently with water and chose option **B**. Other candidates were more likely to think that magnesium is formed by heating its oxide with carbon and chose option **C**.

Question 28

Cryolite is the solvent into which purified aluminium oxide is dissolved. This occurs at a lower temperature than the melting point of aluminium oxide. Candidates appear to have confused this with lowering the melting point of aluminium and so chose option **D**.

Question 29

Nearly half of the candidates who performed less well overall thought that cobalt(II) chloride paper would identify carbon dioxide and chose option **A**.

Question 31

Nearly all the better performing candidates answered this correctly. Other candidates were more likely to choose option **B**

Question 32

Most candidates were able to identify one of the two addition products. Some candidates confused the addition product of ethene and bromine and choose option **C**.

Question 34

Some candidates found this a challenging question and did not recognise the structure of an ester and chose option **D**. The other two distractors were also more likely to be chosen than the correct answer for candidates who performed less well overall.

Question 37

The most popular answer to this question was option **A**. Candidates should recognise that in the substitution reaction, a hydrogen atom is removed and replaced by a chlorine atom. Methane with four hydrogen atoms could therefore give four different products.

CHEMISTRY

Paper 0971/31
Paper 3 Theory (Core)

Key messages

- Candidates would benefit from learning the syllabus definitions of chemical terms and processes.
- Candidates should avoid restating information given in the question as their answer.
- Interpretation of data and chemical reactivity was well done.
- The drawing of the dot-and-cross diagram was well done, as was the calculation of relative molecular mass.
- The descriptions of diffusion were often clear and well written.

General comments

Many candidates performed well on this paper, showing a good understanding of core chemistry. The standard of English was good, and few candidates left questions unanswered.

Chemical tests were not well recalled. For example, **Question 1(e)**, candidates commonly confused the green precipitate with the green colour of chlorine gas or the green flame test colour of copper. In **Question 2(d)**, the test for chlorine was confused with the test for chloride ions. In **Question 4(f)**, the indicator thymolphthalein appeared to be unfamiliar to many candidates.

Some candidates need to practice writing the formal definition for key chemical terms. For example, in **Question 3(d)(i)**, many candidates were unable to distinguish between a hydrated salt and an aqueous solution. Many definitions were too vague. In **Question 4(a)**, many candidates recognised that the number of protons and neutrons should be a part of their answer but did not recall that isotopes are described in terms of atoms which contain those particles. In **Question 5(c)(i)**, some candidates were unclear whether a metal was an essential part of an alloy or whether an alloy is a mixture or a compound. In **Question 7(b)**, most candidates recalled that members of an homologous series share the same functional group but did not show that they understood that the members must all be (organic) compounds. Some candidates suggested that the members of a homologous series must be hydrocarbons, which is only correct for alkane and alkenes but not alcohols or other functional groups. In **Question 8(c)**, most candidates recalled that covalent bonds are most commonly formed between non-metals but did not describe what the bond was. Candidates should recall that a bond is the attraction between the two bonded atoms and the shared pair of electrons.

Some candidates confused observations with inferences. In **Question 4(d)**, some candidates named chemicals as observations rather than the product and some named the electrode as an observation such as ‘cathode’ or ‘anode’.

Candidates should take care when writing chemical names. A common error in **Question 4(e)** was to give sulfide rather than sulfate. Similarly in **Question 7(c)**, ‘ethanoate’ was commonly mis-spelled. In **Question 7(e)**, the ‘e’ in ethene must be clear. Some candidates wrote in such a way that it was unclear whether they were giving ethene or ethane. Many candidates were unable to identify the ammonium ion, NH_4^+, in **Question 3(c)(ii).**

Comments on specific questions

Question 1

This was the best answered question on the paper. Most candidates were able to answer at least three parts of the question, with **(a)**, **(b)** and **(f)** most commonly correct.

(a) Most candidates recalled nitrogen, N or N_2, as forming 78% of clean, dry air. The most common error was to suggest oxygen, O or O_2, or hydrogen, H.

(b) Most candidates identified helium as the only element shown which has atoms with a complete outer electron shell. The most common errors were to suggest oxygen, O, or hydrogen, H.

(c) Only a minority of candidates identified iodine, I. Most candidates confused the number of occupied electron shells with the group number and suggested nitrogen, N. A smaller number suggested iron, Fe, or bromine, Br.

(d) Many candidates confused the charge and group number and suggested magnesium, Mg, or calcium, Ca. A smaller number suggested elements which form ions with a charge of 1– such as chlorine, C*l* or bromine, Br.

(e) The cation test for iron(II) was not well recalled. It was most commonly confused with the green of chlorine gas. Copper, Cu, was also seen, although it was a less common error.

(f) The use of aluminium, A*l*, in food containers was recalled by the majority of candidates. Common errors included iron and a small but significant number of candidates suggested a gaseous element such as oxygen, O, or helium, He.

Question 2

Most candidates answered **Questions 2(a)(ii), 2(b)(i)** and **2(c)** well. **Question 2(a)(iii)** discriminated well between candidates with the candidates who performed less well gaining just one mark for the physical state or zero marks by not identifying the correct state at all. **Question 2(b)(ii)** also discriminated well with weaker responses often comparing the reactivity of iodine with potassium or by giving a vague answer such as 'they do not react'.

(a) (i) Many candidates did not use the boiling point information and did not realise that the melting point must be lower than the boiling point. Predictions of the melting point were frequently much too high. Some candidates found the positive and negative values difficult to interpret. They tended to find the average or middle point of +101 and +114 to suggest +108.

(ii) This question was well answered by most candidates.

(iii) Many candidates deduced the correct physical state but did not give a clear reason. Simply stating the melting and/or boiling points is not sufficient as an explanation. Candidates must state whether the given temperature is higher or lower than those values. Many candidates did not appear to engage with the data and suggested that –10 °C was between the melting point, –101 °C and boiling point, –35 °C. Some candidates did not use the correct element's data.

(b) (i) This question was well answered by most candidates. Neutralisation was the most common incorrect answer.

(ii) This question was not so well answered. Many candidates incorrectly described the relative reactivity of iodine and potassium or iodine and potassium chloride. Some were not clear which substances they were comparing, giving an answer such as 'it is less reactive'. The comparison must be clearly made between the reactivity of iodine and of chlorine (not chloride).

(c) Most candidates drew the correct electron configuration for a chlorine atom. A small number of candidates did not attempt the question or gave the configuration of a chloride ion, Cl^-.

(d) The test for chlorine was not well recalled. The most common error was to confuse it with the test for chloride ions using aqueous silver nitrate to produce a white precipitate. Some candidates confused the test with the flame test for copper ions, perhaps linking the green colours. A small number of candidates were awarded just one mark for identifying the use of litmus paper but not the correct observation.

Question 3

Most candidates gained at least three marks in this question. **Questions 3(a), 3(c)(i) and 3c(iii)** being the most accessible. The effect of nitrates on aquatic life in **Question 3(b)(ii)** was not well recalled, with many guessing answers such as 'it kills fish' or it's toxic.

(a) Most candidates recalled that oxygen is essential for aquatic life. Hydrogen was the most common incorrect answer.

(b) (i) A wide range of possible answers were accepted for this question although most of those who answered correctly suggested sewage or harmful microbes. The most common incorrect answers showed some confusion between water pollutants with air pollutants. Gases such as carbon monoxide or methane were commonly seen.

Many candidates named a substance already listed in the question.

(ii) This question was not well answered. Many candidates confused nitrates in water with oxides of nitrogen and suggested breathing difficulties. Some candidates did correctly recall that the concentration of oxygen would fall, and some stated the term 'eutrophication' which was also accepted. The most common answers were to state that 'it kills fish' or that 'it's toxic', which are insufficient. Reference should be made to the level of oxygen present to sustain life.

(c) (i) Most candidates identified hydrogencarbonate either by name, formula or by its mass. The most common incorrect answer was silicate.

(ii) There were many incorrect answers including 'nitrogen hydroxide' or 'nitronium'. Some candidates suggested 'ammonia' or 'ammoniam'. The correct spelling should be given. A small number of candidates suggested 'nitrate', even though the correct formula of the nitrate ion is given in the table.

(iii) Most candidates answered this correctly. The most common incorrect answers were factors of 10 different. These were 4.4 or 44 mg.

(d) (i) The definition of hydration was not well recalled. Many candidates confused hydration with hydrogenation or aqueous solution. Although many recognised the association with water, the common incorrect answer 'it contains water' is too vague. Answers must be clear that the substance is chemically combined with water.

(ii) Many candidates recognised that the reaction is reversible but did not state how to reverse the reaction. Some candidates did not read the question clearly enough and described the colour changes. A description of the action taken (heating) was required rather than a description of what that action would do such as 'remove the water' or 'evaporate water'.

(e) Most candidates gained at least one mark in this question. The most common error was to suggest 2H rather than H_2 as the product. Some candidates suggested water, H_2O, would also be the product.

Question 4

Many candidates only showed a partial understanding of energy changes and electrolysis. In **Question 4(a)**, most candidates recalled that isotopes (of the same element) had different numbers of neutrons or the same number of protons, but few described that these isotopes were atoms. In **Question 4(d)**, many candidates did not read the question carefully enough and gave the cathode and anode rather than cathode and electrolyte. In **Question 4(e)**, some candidates gave chemical formulae rather than chemical names for the word equation.

(a) Most candidates gained one mark here. The most common error was to omit the word 'atom'. Isotopes must be described in terms of atoms. Candidates may describe atoms having different mass numbers, but they must not describe the atoms as having different *relative* masses because this is an average value of the isotopes not the mass of an individual isotope.

Candidates must also state that isotopes of the same element have different *numbers* of neutrons not that they are different neutrons.

(b) Most candidates identified the number of protons in the sulfide ion. Slightly fewer identified the number of neutrons and few identified the number of electrons. Common errors were to give the mass number as the number of neutrons or to give the number of electrons as 16 or 14.

(c) (i) Most candidates answered this correctly. A small number transposed the reactants and products. Some candidates did not attempt the question at all.

(ii) Candidates were asked to use the figure given to answer this question. Although some candidates correctly described an exothermic reaction either in terms of the surroundings getting warmer or releasing energy, this does not show how the reaction pathway diagram shows that the reaction is exothermic. Candidates should have compared the relative energy of the reactants and the product from the diagram.

(iii) Most candidates answered this correctly. The most common incorrect answer was ‘products’.

(d)(i) When adding labels to a diagram, candidates must take care that their arrow or line clearly identifies the part they are labelling. A label on the tank for the electrolyte is ambiguous.

Candidates should label the electrode when labelling the cathode or anode and not the wire or the power supply.

(ii) Although a few candidates were awarded full credit in this question, many did not answer the question. The most common incorrect answers were to describe the names of the electrodes as anode and cathode or to identify the ions that would be attracted to each electrode as anion and cation. When asked for observations, candidates should describe what they would see, e.g. ‘bubbles of a colourless gas’.

The most common correct answers were to identify hydrogen produced at the negative electrode as ‘bubbles’ or ‘fizzing’. Many candidates correctly identified hydrogen and oxygen but placed them at the wrong electrode. Some candidates suggested sulfur or graphite as products.

(e) Most candidates gained at least two marks in this question. Most identified sodium sulfate but a common mistake was to give sodium sulfide. Some candidates suggested hydrogen would be produced rather than water. Candidates should take care to give chemical names rather than formulae when asked to complete a word equation.

(f) Thymolphthalein was not a well-known indicator. Most candidates confused it with phenolphthalein or methyl orange.

Question 5

Candidates need more practice in answering questions on each stage in the blast furnace. In **Question 5(b)**, many candidates confused the processes. Some candidates simply restated the question and suggested ‘it is used to extract iron’.

(a) Most candidates were able to identify at least one physical difference between iron and potassium. Common errors were to give chemical differences or to confuse the properties of the metals and so to describe potassium as being hard or having a high melting point.

Candidates should note that high melting point and high boiling point are not considered as two different marking points.

When asked to give two differences, candidates should follow the rubric of the question and only give two differences to reduce the possibility of giving a contradictory answer.

(b) The better performing candidates gave clear, well described answers to this question. Across all candidates, the use of carbon in the blast furnace was not well recalled. Many candidates incorrectly suggested that carbon was a catalyst in the extraction of iron from iron ore or that it was involved in the formation of slag. Some candidates repeated the question by stating that it is used to extract iron without reference to the processes involved.

(c) (i) Most candidates recalled that a metal was required, although many did not use the word 'mixture' or thought that an alloy was a metal compound. Some candidates gave an answer which was too vague such as 'usually contains a metal', which may incorrectly suggest that a metal is not required or that the metal is mixed with a 'substance' rather than another element.

(ii) This question required candidates to make a comparison between an alloy and a pure metal. Many candidates suggested a property which was common to both such as 'it is malleable' or 'conducts electricity'. A comparative statement such as strong<u>er</u> or hard<u>er</u> was required.

(d) Most candidates gave the correct order of reactivity for these metals. Only a few gave the reverse order or an incorrect order. A few candidates confused the information given and used the word 'metal' in their answers.

Question 6

In **Questions 6(a)(i)** and **6(a)(ii)** and **6(a)(iii)**, candidates found it difficult to distinguish between the reaction rate and the time for the reaction to complete. When asked how to separate a solid and a solution, candidates seemed more likely to describe filtration than when they were given a specific example as showing in **Question 6(b).** The solubility rules for **Question 6(c)** were not well recalled.

(a) (i) Candidates found this to be a challenging question. The most common answer was 2, 1, 1.5.

(ii)(iii)
Many candidates recognised the effect on rate but did not distinguish between reaction rate and reaction time. Many gave vague answers which could be interpreted to mean time or rate such as 'faster'. Some candidates described both the rate and the time which was acceptable.

(b) Most candidates answered this correctly. 'Crystallisation' was the most common incorrect answer.

(c) Many candidates did not recall the solubility rules. Many incorrectly chose silver chloride, which is also covered by the cation tests.

Question 7

Candidates found the definition in **Question 7(b)** difficult with many only gaining one mark. Although many were not awarded both marks in **Question 7(c)**, some gave perfect answers with the correct spelling of magnesium ethanoate. The reactions which produce ethanol need more practice (**Question 7(e)**).

(a) (i) Most candidates were able to identify the carboxyl groups. A few chose the C=C double bond and a small number either did not answer the question or chose the –OH group. If a candidate changes their mind, they should make it clear which answer they are rejecting. Some candidates circled more than one different functional group and so could not be awarded credit.

(ii) This question was well answered but some candidates were careless with their chemical symbols. When writing a chemical formula, the subscripts must be clearly lower than the chemical symbols and those symbols must be in uppercase for carbon, hydrogen and oxygen.

(iii) Many candidates identified the correct colours but reversed the order.

(b) Few candidates were awarded full credit for this question. Those that were awarded one mark stated that members of the same homologous series shared the same functional group. A small number of candidates incorrectly suggested they shared a similar functional group. Few candidates stated that the substances are all molecules or compounds, with many confusing homologous series with groups from the Periodic Table.

(c) Candidates are expected to use the correct spelling using IUPAC nomenclature. Many candidates gave near-miss spellings for ethanoate such as 'ethanate' or 'ethanoic'. A small number incorrectly suggested 'magnesium hydroxide'. Candidates should recall that acids such as ethanoic acid will react to give similar products to those of mineral acids. Its reaction with magnesium will produce hydrogen and not water.

(d) This question was well answered with most candidates being awarded full credit.

(e) Most candidates gave the reaction mixture for fermentation, glucose or starch and yeast rather than the other method (addition) required by the question. Some candidates may have written the correct answer, ethene, but they wrote in such a way that it was hard to determine whether they had written ‘ethene’ or ‘ethane’. If the answer is ambiguous then credit cannot be awarded.

A significant number of candidates did not attempt this question.

Question 8

In **Question 8(a)**, some candidates showed poor understanding of the difference between chemical and physical properties. Many answers were vague such as giving ‘factories’ as a source of oxides of nitrogen and ‘causes illness’ or ‘are harmful’ for their effects. Most candidates identified a suitable pH for an alkaline solution in **Question 8(c)(iii)**. The longer descriptive answers given for **Question 8(c)(iv)** were often detailed and accurate.

(a) When asked for two properties, candidates must take care to only give two properties to avoid possible contradictions. They should also note that low boiling point would be the same marking point as low melting point. Many candidates simply repeated the property from the question or gave chemical rather than physical properties.

(b) (i) When asked for the source of pollutant gases, candidates frequently suggested ‘factories’ which is too vague. Similarly, ‘burning fuels’ was incorrect because hydrogen, when uses as a fuel, does not produce polluting gases.

(ii) The problems associated with oxides of nitrogen were not well recalled. Answers needed to give a clear problem with respiration or breathing or irritation of the skin or eyes. Many candidates restated the information in the question and suggested ‘acid rain’. Some confused oxides of nitrogen with other gaseous pollutants or nitrates.

(c) (i) This question was the least well answered question on this paper. The formal definition was not well recalled. Very few candidates recognised that a covalent bond would connect two atoms. Although most candidates correctly answered **(c)(ii)**, few recognised that the bond would contain two shared electrons. The most common error was to describe properties of covalent compounds such as low melting point or poor conductivity. Some candidates gave answers which were close such as ‘non-metals which share electrons’.

(ii) Most candidates were awarded full credit here. The most common error was to give only one non-bonding electron or to omit the non-bonding electrons completely.

(iii) Most candidates answered this question correctly.

(iv) Candidates often gave well-written and clear descriptions to describe diffusion. Many candidates gained full credit and covered all the possible marking points. Most candidates identified that the process was diffusion and that there was movement from higher concentration to lower concentrations of ammonia. Those that did not gain all three marks often gave an answer that did not use particles or molecules of ammonia and simple described the movement of gas. Some candidates spent more time describing why the litmus changed colour rather than the movement of particles to the litmus.

CHEMISTRY

Paper 0971/32
Theory (Core) 32

There were too few candidates for a meaningful report to be produced.

CHEMISTRY

Paper 0971/41
Paper 4 Theory (Extended)

Key messages

- When writing formulae:
  - superscripts in ions should be written above the symbol and smaller than the symbol e.g. Pb^{2+} as opposed to Pb2+
  - subscripts should be written below the line and smaller than the symbol e.g. H_2O as opposed to H2O
  - lowercase letters should be smaller than upper case letters e.g. Na_2O as opposed to NA₂O.
- Candidates should understand the following regarding precipitation reactions:
  - how to use information concerning solubility rules to deduce which two aqueous solutions can be used to form a precipitate
  - how to write ionic equations (including state symbols) for precipitation reactions
  - practical details of how to separate and purify an insoluble solid formed in a precipitation reaction
- If a question asks for a name, it is inappropriate to give a formula or an equation.
- If a question asks for a formula, it is inappropriate to give an equation or a name.

Comments on specific questions

Question 1

(a) This equation was recognised by a minority of candidates.

(b) This was answered correctly by only a small number of candidates. Equation **I** was a common wrong answer.

(c) This was answered correctly by a large number of candidates.

(d) This was answered correctly by a large number of candidates.

(e) This was answered reasonably well.

(f) This was answered correctly by a large number of candidates.

Question 2

(a) (i) This was answered correctly by a large number of candidates. 'O' was seen occasionally as the answer.

(ii) This was answered correctly by a large number of candidates. 'Li' was a common wrong answer.

(iii) This was answered correctly by a large number of candidates. 'Be' was a common wrong answer

(iv) This was answered correctly by a large number of candidates.

(v) This was answered correctly by a large number of candidates.

(vi) This was answered reasonably well. 'O' was seen most often as an incorrect answer.

(b) (i) Many candidates omitted a reference to atoms. Statements about the same number of protons and different numbers of neutrons were often correct.

(ii) There were many good answers to this calculation. Most candidates gave their answer to one decimal place as requested. The most common error was to add 10 and 11 and divide by 2 giving an answer of 10.5. A small number of candidates rounded up to 11 or 11.0. It is important that candidates show all working out in calculations.

Question 3

(a) (i) The most common error was to show only 7 electrons in the outer shell of the oxide ions. This was presumably because candidates were unaware that **two** sodium atoms donated one electron each to the oxygen atom.

(ii) This was answered reasonably well. Some gave an equation instead of a formula. Candidates should be aware that a formula begins with a symbol as opposed to a number.

(b) This was answered reasonably well. The majority of candidates showed two pairs of bonding electrons in both bonds. Common errors included too many non-bonding electrons on the oxygen atoms and non-bonding electrons on the carbon atom. These problems were caused because candidates were unaware that the number of electrons available was different to four from the carbon atom and six from each oxygen atom.

(c) (i) Many candidates referred to ionic bonding and then went on to contradict themselves by reference to atoms or molecules. Some referred to strong forces instead of strong forces of attraction.

There was no requirement to compare sodium oxide with carbon dioxide. Many candidates misread the question in this respect.

(ii) Covalent bonding was seen just as often as the correct answer.

Question 4

(a) The vast majority of candidates stated that catalysts increase the rate of a reaction. A statement that catalysts are not used up was common. This means that there is some catalyst remaining at the end. However, all the catalyst remains unchanged at the end of the reaction. This needed to be stated. Lowering activation energy was also occasionally seen, which gained credit.

(b) (i) Candidates should realise that the decrease in mass can only be due to matter leaving or escaping from the apparatus. In this case, the gas in question was gaseous oxygen. 'Oxygen being given off or produced' was insufficient to gain credit. The gaseous product was sometimes thought to be hydrogen.

(ii) Rate of reaction depends on concentration as opposed to mass or volume or amount, all of which were frequently seen. The reaction is fastest at the start of the reaction because the concentration of hydrogen peroxide is at its highest at the start.

(iii) The majority of candidates omitted to mention that the rate of reaction becomes zero because all the hydrogen peroxide is used up. It was fairly common to see statements that the amount of catalyst had decreased.

(c) Many candidates stated that particles gained kinetic energy and moved faster. Candidates sometimes mentioned an increased number of collisions as opposed to an increased collision frequency. Only a few candidates referred to activation energy. Those that did, often made partially correct or wholly incorrect statements.

Other common errors seen were: not mentioning particles anywhere in the response; describing 'more collisions' or 'increased chance of collisions' rather than increased collision frequency.

(d) This calculation was answered reasonably well. A common error was to multiply the number of moles of O_2 by either 24 or 16 instead of 32.

(e) A catalyst increases the rate of a reaction without having any effect on the amount of substance produced. The mass of oxygen produced in this reaction depends totally on the amount of hydrogen peroxide used. Changing the mass of catalyst has no effect.

(f) Candidates performed poorly on this question. The formula of mercury(II) oxide was often incorrect, despite it being given. The formula of oxygen was often written as O. Hg_2 was also seen.

The equation was sometimes unbalanced even if the formulae were all correct. Some attempted to write the reactants as products and vice versa.

Question 5

(a) (i) Many candidates repeated the definition of electrolysis that they had learned. Those who used different terminology often produced incomplete or misleading statements.

(ii) Many stated that graphite was inert or a conductor of electricity. Very few made both statements that were required.

(iii) This was answered reasonably well. Common errors included the wrong charge on the hydrogen ion and the formula of hydrogen written as H.

(iv) This was answered quite well. Ion was the most common incorrect answer.

(v) This was answered less well. Electron and proton were the most common incorrect answers.

(vi) The syllabus makes a distinction between dilute and concentrated aqueous halide solutions as electrolytes. Therefore oxygen, as opposed to bromine, is the anode product when the electrolyte is dilute aqueous potassium bromide.

Potassium was occasionally seen as the cathode product.

(b) (i) This was answered reasonably well. There were no common incorrect answers.

(ii) Incorrect statements about melting points were common. The melting point of aluminium oxide is fixed and cannot be changed by the use of cryolite. Answers that referred to boiling point similarly went uncredited.

Cryolite as a catalyst was commonly seen. The function of cryolite as a solvent was rarely mentioned. There were many references to cryolite as an electrical conductor itself rather than stating that cryolite increased the conductivity of the electrolyte.

(iii) The conversion of the carbon anode to carbon dioxide was only mentioned by a minority of candidates.

(c) (i) A minority of candidates were aware that the equation for the reaction in a hydrogen–oxygen fuel cell is the same as that for the combustion of hydrogen in oxygen. H and O were often seen as incorrect formulae. H_2O was only seen occasionally as the product.

(ii) Most answers were vague and non-specific, such as:

- no pollution
- not environmentally friendly
- no toxic products
- renewable, without reference to oxygen or hydrogen.

The correct answer needed to refer specifically to the hydrogen–oxygen fuel cell and its comparison with petrol in vehicle engines.

Question 6

(a) (i) The equation was balanced by a majority of candidates. '7' was occasionally seen in front of O_2. In some cases, crossings out made candidate responses difficult to read.

(ii) There were many misunderstandings regarding this question. Some merely gave the oxidation number of iron without naming the compound. Iron(II) oxide was commonly seen as was iron(III) trioxide.

(b) (i) Candidates answered this question reasonably well. Some suggested that enzyme denaturation was the reason for not using a greater temperature. One error was to refer to the ‘exothermic side’.

(ii) Candidates found this somewhat less challenging than **(b)(i)**. One error was to refer to the reaction with fewer molecules.

(c) Only a small number of candidates were able to write the correct formula of ammonium sulfate. Others gave additional products, namely H_2 or H_2O.

(d) (i) Only a small percentage of candidates knew that all nitrates are soluble in water.

(ii) This was poorly answered.

Ionic equations for precipitation reactions should include the aqueous ions on the left-hand side and the solid precipitate on the right. The formula of lead(II) sulfate was often wrong, either Pb_2SO_4 or $Pb(SO_4)_2$. Many equations included other species.

(iii) Those who correctly started with filtration then went on to describe crystallisation of the aqueous filtrate instead of purification of the residue. Those who decided to wash and dry the residue often omitted sufficient detail of how to do this to obtain any credit.

Question 7

(a) (i) This was answered quite well. Some candidates focused on the substitution reaction rather than the need for ultraviolet light.

(ii) This was answered reasonably well. Common errors were to include branched chain isomers or to draw the same isomer twice.

(b) (i) Attempts at structural formulae or names instead of molecular formulae were quite common.

(ii) This was answered very well. Spelling ‘carboxylic’ was often challenging.

(iii) Answers were often descriptions other than observations, as well as incorrect observations, the most common of which was a ‘precipitate forming’.

(iv) This was answered reasonably well. There was no requirement for brackets or –n when drawing a repeat unit. Many answers contained carbon–carbon double bonds. Connectivity issues involving the two carbon atoms in the main polymer chain being bonded to –COOH and $–CH_2OH$.

(v) Candidates found this challenging. Common answers included esters and named polymers such as Terylene, PET and polyamides.

CHEMISTRY

Paper 0971/42
Paper 4 Theory (Extended)

Key messages

- Where candidates are required to select an answer from a set of possible choices, such as **Question 1**, then they should be encouraged to make sensible guesses rather than leaving an answer blank. There is no penalty for an incorrect attempt.
- Candidates should not provide fractions as answers to calculations such as **Question 4(g)**.
- In extended questions such **Question 3 (b)(v)**, candidates are advised to present their answers in short, concise sentences. The use of bullet points helps to prevent long, rambling sentences which tend to lead to repetition of some facts and often show contradictions to earlier correct answers.

General comments

The overall standard was very high, but this was the first June examination following a syllabus update and it was noticeable that some candidates were not familiar with the newer content of the syllabus.

Candidates need to be careful in the use of subscripts in formulae and upper/lower case in symbols.

If a single answer is asked for, two or three answers should not be given, as incorrect statements may contradict correct answers. There were many incidences of candidates giving more than one answer where only one was required and thus not gaining credit.

Comments on specific questions

Question 1

This question required choices from eight metal oxides given in the question.

Most candidates performed well overall with **(a)**, **(b)** and **(d)** usually being correct.

Parts **(c)** and **(f)** proved more difficult and **(e)** was the hardest, with only about one-third of the candidates getting this correct because the majority assumed iron(III) oxide was the main impurity of iron ore.

Question 2

(a) Most candidates correctly named elements in Group VII as ‘halogens’ with ‘halide’ being the most common error.

(b) A significant number of candidates omitted the word ‘number’ and wrote ‘same electron’ in the outermost shell’. This did not get credit.

Although not incorrect, many candidates referred to the outermost shell electrons as ‘valence shell electrons’ – a term that has not been used in this syllabus for many years.

(c) The colours and states of the halogens are now given in the syllabus. Chlorine was expected to be pale yellow-green in colour and bromine to be red-brown. Candidates who performed less well assumed elemental bromine to be orange, probably because of confusion with bromine water.

(d) (i) The term nucleon number or its alternative, mass number, was not well known.

(ii) The majority of candidates who performed well gained three marks. Occasionally, the neutron row was seen as 79 and 81.

(iii) Most candidates realised that isotopic mass × abundance was significant. These candidates were able to determine the average of this value to one decimal place. A significant number then changed their answer from 79.9 in the working to 80 or 80.0 on the answer line.

(e) (i) Most candidates worked out that KCl was formed but many made errors in the rest of the equation such as Br instead of Br_2 for bromine.

(ii) Most realised the reaction did not happen because chlorine was less reactive than fluorine.

(f) (i) The formation of a white precipitate was known by most. Some candidates incorrectly described effervescence.

(ii) A significant number of candidates wrote symbol equations rather than ionic equations. Of those who attempted ionic equations, some left spectator ions in their final answer.

Many candidates made various attempts as part of their working, both above and below the answer line, but a significant number did not cross through unwanted material on the answer line giving rise to an incorrect answer as well as the correct answer.

Question 3

(a) The name of the Contact process was quite well known, with only a few opting for the Haber process.

(b) (i) This question relied upon knowledge of the new syllabus in LO 6.3.9. Neither burning sulfur or roasting sulfide ores was well known.

(ii) Some candidates were able to describe equilibria; others needed to take care with wording.

Vague statements such as, ‘the forward reaction equals the reverse reaction’ were seen, which has no reference to *rate* of these reactions. ‘Concentrations of products and reactants are the same’ was also too vague. Better responses stated, ‘concentrations of products and reactants *stay* the same’.

(iii) The temperature and identity of the catalyst were well known, but the value of the pressure in kPa, less so. The conditions given in LO 6.3.10 of the syllabus were expected. ‘2 kPa’ was a frequent error. The oxidation state of vanadium in the catalyst was often incorrect.

(iv) Most candidates coped well with predicting effect of changing the conditions.

(v) Some candidates were able to explain why changing the temperature changes the rate of reaction. Most knew the energy decreases and could state the frequency of collisions decreases – often seen as ‘less collisions per unit time’. Candidates who performed less well tended to simply state there were ‘less collisions’ without reference to frequency. Few candidates appreciated that a lower percentage of particles have energy greater than activation energy. However, many candidates wrote phrases such as ‘particles have energy lower than activation energy’, suggesting all particles had energy lower than activation energy.

Some candidates erroneously stated activation energy is changed.

(c) Many candidates found this question very challenging and were clearly unfamiliar with the method needed to solve the problem. Candidates need to be aware that a key part of an oxidation number is the positive or negative sign preceding the integer. Integers alone are not oxidation numbers.

Question 4

(a) Most candidates knew that a base was a proton acceptor. Phrases about neutralizing acids or pH values were ignored.

(b) Most candidates knew that a soluble base is known as an alkali.

(c) The colour of thymolphthalein in alkali was well known.

(d) The names of the products of this word equation were well known. Sodium chloride was almost universally known. Occasionally, 'ammonia' was incorrectly written as 'ammonium' and 'hydrogen' frequently appeared instead of 'water'.

(e) (i) Candidates performed poorly on this question and a very common incorrect answer was 'acidic'. Better performing candidates were able to work out that the correct term was 'amphoteric'.

(ii) Although candidates may not have been correct in their answer to **(e)(i)**, many named one of the two examples of amphoteric oxides given in the syllabus.

(f) (i) The dot-and-cross diagram of ethanoic was done well by candidates who performed well, with each covalent bond being represented by a dot and cross. Although not necessary, some candidates felt the need to introduce a third symbol for electrons belonging to hydrogen atoms. Candidates who used a pair of the same symbols for a covalent bond did not receive full credit.

Candidates who performed less well did not show the non-bonding electrons on both oxygen atoms. Some of these candidates were able to gain credit for the single dot and cross bonds or the dot and cross double bond.

(ii) Nearly all candidates gave a pH within the acceptable range. It should be noted that an answer such as pH ≤ 7 would not get credit because the pH could not equal 7 and the pH of a strong acid, e.g. 2, fits this expression.

(iii) Only the better performing candidates gained full credit. The most common error was to use a one directional arrow instead of the reversible arrows.

Weaker responses were able to gain credit for a single H^+ ion as a product. Many incorrectly gave $4H^+$ as a product, suggesting that all hydrogen atoms in CH_3COOH ionised. Very few of these responses gave the CH_3COO^- anion formed.

(iv) Only the better performing candidates could recall this new part of the new syllabus from LO 7.1.8.

(g) A wide range of marks was seen here with the better performing candidates gaining full credit.

Candidates should be reminded that fractions as answers to calculations will not receive credit in this chemistry exam. Candidates should also be reminded that leaving the M_r calculation as a sum such as 2 + 32 + 64 may also not receive full credit.

Question 5

(a)(i)(iv) These questions were based upon LO 11.4.4 of the new syllabus.

Most candidates performed well with **(i)** and **(iii)** and substitution and photochemical were seen frequently. In **(ii)**, the idea of ultraviolet light providing the activation energy needed for the reaction was not known.

In **(iv)**, some candidates opted for 'disubstitution', despite the wording of the question.

(b) (i) Many responses were too vague. It was important that a candidate referred to carbon–carbon bonds in their answer. An answer such as, 'here is a carbon double bond' is insufficient as the double bond could be to another atom such as oxygen in carboxylic acids.

(ii) Better performing candidates tended to give the correct structural formula of 1,2-dichloropropane. Many gave either 1,3-dichloropropane or 1,1-dichloropropane as incorrect answers. Other candidates gave ambiguous formulae such as $C_3H_6Cl_2$.

(c) Of the candidates who knew the answer, the correct name of propan-2-ol was frequently given but the same candidates referred to propan-1-ol as 'propanol'. Others were unaware of the IUPAC system of naming alcohols with more than two carbon atoms.

Many of these candidates drew the displayed formulae incorrectly because of omitting the O–H bond.

Question 6

(a) The name of the ester was known by most candidates. The most common error was the misspelling of 'butanoate' as 'butanote'.

(b) The identity of water as the product in an esterification reaction was well known, but various incorrect answers such as 'hydrogen' or the names of other esters were seen.

(c) Most candidates were unable to deduce the empirical formula of the ester with many simply stating the molecular formula rather than recognising the need to cancel this down to the simplest whole number ratio.

(d) (i) Candidates who chose to circle a repeat unit, starting at one of the ends of the given structure, tended to be more successful than those who circled a unit in the middle. Some candidates simply circled the ester linkage.

(ii) A wide range of responses was seen here. Many candidates did not appreciate that monomers do not have continuation bonds and are discrete molecules.

Other frequently seen errors included connecting the O–H bonds to the box via the hydrogen atom, thus creating divalent H atoms or transposing correctly drawn groups to the wrong box.

(iii) Most candidates recognised this as condensation polymerisation.

CHEMISTRY

Paper 0971/51
Paper 5 Practical Test

Key messages

- The Confidential Instructions state that the supervisor must do the experiments in **Questions 1** and **2** and record the results on a copy of the Question Paper. These results must then be included with the scripts from the centre when they are returned. Where the practical exam has taken place in more than one practical session or laboratory, it should be clear which set of supervisor's results are for which session or laboratory and also which candidates were in which session or laboratory.
- It is essential that centres make up solutions and provide apparatus in accordance with the details contained in the Confidential Instructions. If there is difficulty in obtaining some substances, then the centre should contact Cambridge for advice.
- Readings recorded from a given item of apparatus should all be recorded to the same resolution (the same number of decimal places).
- When a question asks for the name of a chemical, a correct formula is always acceptable. However, an incorrect formula will contradict a correct name.
- In the qualitative analysis question (**Question 2**) where a question states, 'Test any gas produced', candidates are expected to test the gas and record the details for the gas test that gave a positive result. Candidates are expected to use the term 'precipitate' when describing the formation of a solid from the reaction between two solutions; if when two solutions are mixed the product becomes cloudy and opaque then a precipitate has been formed.
- In qualitative analysis, not all of the tests described will necessarily give a positive result; a negative test result is useful since it informs that a certain ion is **not** in the compound being tested.

General comments

The vast majority of candidates successfully attempted all of the questions. The paper was generally well answered, with very few blank spaces.

In answering the planning question (**Question 3**), there is no need for candidates to spend time writing a list of variables or to write a list of apparatus at the start, nor the aims of the experiment. Where there is credit available for the use of suitable apparatus, then that is only awarded if it is stated what the apparatus is used for; credit will not be awarded just for a name in a list of other apparatus.

Comments on specific questions

Question 1

(a) Candidates performed well on this part, with most being able to read burette scales and calculate the volumes added. A large number of responses did not give all burette readings to a consistent number of decimal places, for example 21 rather than 21.0. Some candidates gave readings to a consistent number of significant figures, rather than decimal places and so, for example, recorded the numbers such as 9.20 alongside 21.0. All readings should be to a consistent number of decimal places. A small minority of candidates added the two burette readings to calculate the titre rather than subtracted them. Others recorded some of the readings as 25 or 50 cm^3, suggesting a lack of familiarity with titrations.

(b) The reason for use of a white tile in the titration caused some candidates a problem. The better candidates could state 'it enabled the colour change or the cloudiness due to the precipitate to be seen more clearly'. It was not sufficient to just say that the tile 'allowed the colours to be seen' – they can be seen anyway but the tile makes them clearer. Other common errors were to state the tile protected the bench or lifted the flask up higher.

(c) (i) Most candidates correctly stated that rinsing with water was to clean the burette and conical flask by removing residues from the previous experiment.

(ii) This proved more demanding than **(c)(i)**, although many candidates stated the need to remove water (as it would dilute solution **B**). Some thought that there may still be some solution **A** in the burette despite having just rinsed it with water.

(iii) Many candidates realised that rinsing the flask with aqueous ammonia would result in a small amount of ammonia remaining in the flask. Hence, the flask would contain the 25 cm^3 measured plus the remains from rinsing which would lead to more solution **B** being required. From the answers seen it was evident that some candidates misread the question and thought the burette was being rinsed with aqueous ammonia.

(d) (i) Better performing candidates correctly stated that solution **B** was the more concentrated and correctly explained that a smaller volume of solution **B** than solution **A** reacted with the same volume of aqueous ammonia. A common error was to state that solution **A** was the more concentrated because a greater volume of solution **A** was required.

(ii) The majority of candidates correctly divided the bigger titre by the smaller to produce an answer. However, the most common errors were to divide the smaller titre by the larger, which give an answer of <1 (and so did not answer the question for how many times more concentrated the solution was) or to just subtract one titre from the other and so calculate the difference in the two titres. It was expected that an answer was given to at least one decimal place, correctly rounded if necessary. Thus, answers stating that the volume was nearly doubled were not precise enough to gain credit.

(e) Almost all candidates stated that the experiment should be repeated, but many of those did not go on to say that the answers obtained from the repeated experiments should be compared. Without a comparison of the titres obtained it is not possible to tell if the results obtained are reliable.

(f) Most candidates correctly calculated the expected titre based on the titre obtained in Experiment 1. A common error was to base the calculation on the final burette reading in Experiment 1 rather than the titre. Most candidates remembered that physical quantities require units, although some omitted the units.

(g) Almost all candidates were able to correctly state that a volumetric pipette was more accurate than a measuring cylinder. A range of different disadvantages were seen; the fact that a volumetric pipette only measures a fixed volume is not a disadvantage in this experiment as the volume of aqueous ammonia was 25 cm^3 in every experiment. It was evident that some candidates were not familiar with volumetric pipettes and so were trying to compare the use of a measuring cylinder to a dropping or Pasteur pipette.

Question 2

(a) Whilst most candidates spotted the change in state from a solid to a liquid, far fewer mentioned the condensation on the sides of the boiling tube.

(b) Very few candidates realised that solid **E** was hydrated or contained water (of crystallisation), largely due to lack of a correct observation in **(a)**.

(c) Most candidates observed a red-brown precipitate that did not dissolve in excess, although there were some incorrect descriptions of the colour. Very few candidates appeared to be unfamiliar with the term ‘precipitate’.

(d) The majority of candidates correctly identified ammonia as the gas, although a number did not say that it turned damp red litmus blue as an observation. A few appeared to get positive tests for other gases, usually carbon dioxide, hydrogen or oxygen.

(e) Two colours were required here, the colour immediately after the solutions were mixed and the colour after standing for three minutes (which was back to the original colour). Most candidates just gave one of these colours.

(f) Most candidates correctly described the positive result of this test for sulfate ions.

(g) This test for halide ions should have given a negative result but a number appeared to have seen a white precipitate.

(h) Most candidates correctly saw a red-brown precipitate.

(i) Two colour changes were expected, the brown of the aqueous iodine after addition of aqueous potassium iodide and then the blue-black after the addition of starch solution. Although a few did give both colours, most only gave one - usually the final colour.

(j) This was the test for sulfite ions and the vast majority did get a negative result, with the solution going a pink/purple colour.

(k) Most candidates correctly identified that sulfate ions were present. Iron(III) was also often identified correctly, although some candidates omitted the oxidation state of the iron. The third ion proved much more demanding, with many candidates suggesting incorrectly that nitrate ions were present rather than ammonium ions. A number of candidates chose to use only formulae to represent the ions rather than names and, in some cases, wrote an incorrect ionic charge.

Question 3

Some excellent and succinct descriptions of this preparation were seen, with a good proportion of candidates gaining full credit.

This planning task was a qualitative preparation of cobalt(II) sulfate. As it was a qualitative task, there was no need to measure volumes or masses.

Good responses included the following points:
- add an excess of cobalt(II) oxide to dilute sulfuric acid in a suitable container such as a conical flask
- heat and stir the mixture
- filter the mixture to remove excess cobalt(II) oxide
- evaporate the filtrate by heating to the point of crystallisation
- cool the solution and isolate the dry crystals by filtration or drying the crystals with filter paper.

The most common errors were omissions. Many candidates did not specify that the base should be in excess (although the best candidates explained why it should be in excess), some did not mention any container to carry out the reaction in and some specified an unsuitable container such as a measuring cylinder. Some candidates specified that cold acid should be used and that it would need leaving a long time because the reaction was slow rather than using warmed sulfuric acid.

A small but significant minority of candidates missed out entirely the stages in which cobalt(II) sulfate solution was made and instead chose to start with cobalt(II) sulfate solution.

It should be noted that there is no need for candidates to write a list of aims and apparatus at the start of their answers. The aim of the plan is in the question and credit will not be given for listing items of apparatus; where credit is available for the selection of an appropriate item of apparatus then it must be clear in the plan for what the item of apparatus will be used.

CHEMISTRY

Paper 0971/61
Paper 6 Alternative to Practical

Key messages

- Readings recorded from a given item of apparatus should all be recorded to the same resolution (the same number of decimal places).
- 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 will not be awarded.
- In qualitative analysis, not all the tests described will necessarily give a positive result; a negative test result is useful since it tells us that a certain ion is **not** in the compound being tested.

General comments

The majority of candidates successfully attempted all of the questions. The paper was generally well answered, with very few blank spaces.

In answering the planning question (**Question 4**), there is no need for candidates to spend time writing a list of variables, to write a list of apparatus at the start or the aims of the experiment. Where there is credit available for the use of suitable apparatus, then credit will only be awarded if it is stated what the apparatus is used for. Credit will not be awarded just for a name in a list of other apparatus.

Comments on specific questions

Question 1

(a) The majority of candidates were able to correctly identify **A** as a conical flask.

(b) Many candidates correctly stated that the use of hot water would either speed up the rate of dissolving or would increase the solubility of the sugar so that more would dissolve. A common incorrect answer was to state that higher temperatures increased the rate of the reaction. While it is true that the rate of a reaction is increased by using a higher temperature, there was no reaction occurring at this stage – the process was dissolution.

(c) The majority of candidates correctly named the required process as filtration. However, significantly fewer drew a correct diagram. Common errors were to either omit the funnel or the filter paper.

(d) The question produced a range of answers. Many candidates correctly stated that the enzymes in yeast would be denatured at high temperatures or that fermentation does not occur at high temperatures. A common answer that did not gain credit was to state that the yeast became denatured at high temperatures. Some candidates incorrectly thought that the reaction would become too fast at high temperatures.

(e) The vast majority of candidates correctly stated that the limewater would become milky or cloudy due to the production of carbon dioxide.

(f) Most candidates could state the bubbles would stop being formed when fermentation was complete. Common errors were to state that the limewater would stop changing. While this is true, it is not something which can be readily observed – either the limewater will be cloudy and it will remain cloudy or if so much carbon dioxide has been passed through the limewater that it has turned clear again, then it will just remain clear. Answers stating that no more gas or carbon dioxide was produced, whilst correct statements, did not gain credit as they are not observations.

(g) Most candidates correctly identified distillation as the appropriate process to separate ethanol from the fermentation mixture.

Question 2

(a) Candidates performed well on this question. Most candidates were able to read the burette scales and calculate the volumes added. Many gave all burette readings to a consistent number of decimal places. However, some candidates recorded the initial reading in Experiment 2 as 21 rather than 21.0. Some candidates gave readings to a consistent number of significant figures, rather than decimal places and so, for example, recorded the numbers such as 9.20 alongside 21.0. All readings should be to a consistent number of <u>decimal</u> places. A small minority of candidates added the two burette readings to calculate the titre rather than subtracted them.

(b) The reason for use of a white tile in the titration caused some candidates a problem, possibly due to reduced amount of practical work that some centres have been able to carry out over the last few years. The better performing candidates could state it enabled the colour change or the cloudiness due to the precipitate to be seen more clearly. It was not sufficient to just say that the tile allowed the colours to be seen – they can be seen anyway but the tile makes them clearer. Other common errors were to state the tile protected the bench or lifted the flask up higher.

(c) (i) Most candidates correctly stated that the rinsing with water was to clean the burette and conical flask by removing residues from the previous experiment.

(ii) This proved more demanding than **(c)(i)**. Many candidates stated the need to remove water (as it would dilute solution **B**); some thought that there may still be some solution **A** in the burette despite having just rinsed it with water.

(iii) Many candidates realised that rinsing the flask with aqueous ammonia would result in a small amount of ammonia remaining in the flask. Hence, the flask would contain the $25\,cm^3$ measured plus the remains from rinsing which would lead to more solution **B** being required. From the answers seen, it was evident that some candidates misread the question and thought the burette was being rinsed with aqueous ammonia.

(d) (i) Better performing candidates correctly stated that solution **B** was the more concentrated and correctly explained this by stating that a smaller volume of solution **B** than solution **A** reacted with the same volume of aqueous ammonia. The most common error was to state that solution **A** was the more concentrated because a greater volume of **A** was required.

(ii) The majority of candidates correctly divided the bigger titre by the smaller to produce an answer of $\times 1.5$. However, the most common errors were to divide the smaller titre by the larger which give and answer of <1, and so did not answer the question for how many times more concentrated the solution was, or to just subtract one titre from the other and so calculate the difference in the two titres. Answers stating that the volume was nearly doubled were not precise enough to gain credit.

(e) Almost all candidates stated that the experiment should be repeated, but many of those did not go on to say that the answers obtained from the repeated experiments should be compared. Without a comparison of the titres obtained, it is not possible to tell if the results obtained are reliable.

(f) Most candidates correctly calculated the expected titre based on the titre obtained in Experiment 1. A common error was to base the calculation of the final burette reading in Experiment 1 rather than the titre. Most candidates remembered that physical quantities require units, although some omitted the units and so did not gain credit.

(g) Almost all candidates were able to correctly state that a volumetric pipette was more accurate than a measuring cylinder. A range of different disadvantages were seen. The fact that a volumetric pipette only measures a fixed volume is not a disadvantage in this experiment as the volume of aqueous ammonia was 25 cm^3 in every experiment. It was evident that some candidates may not be familiar with volumetric pipettes and so were trying to compare the use of a measuring cylinder to a dropping or Pasteur pipette.

Question 3

(a) This question proved demanding, with only the better performing candidates realising that the formation of steam and condensation suggested that solid **E** contained water and so was hydrated.

(b) Most candidates correctly identified the gas as ammonia.

(c) **Test 4** in Table 3.1 gave a negative result and so it tells us what was **not** present in solid **E**. As the test described was the test for halide ions, it told us that the ions chloride, bromide and iodide were not present. Some candidates stated that there were no halogens present; this statement was ignored, and credit was not awarded as the test is a test for halide ions and not a halogen.

(d) Most candidates correctly identified that sulfate ions were present. Iron(III) was also often identified correctly, although some candidates omitted the oxidation state of the iron. The third ion proved much more demanding with many candidates suggesting incorrectly that nitrate ions were present rather than ammonium ions. A number of candidates chose to use only formulae to represent the ions rather than names. In some cases, they gave an incorrect ionic charge.

(e) This was well answered, with most candidates correctly stating a white precipitate would form and that the precipitate would dissolve in excess to form a colourless solution.

(f) Almost all candidates correctly described the positive result of this test for sulfite ions.

(g) The answer of 'white precipitate', the positive test result for sulfate ions, was seen as often as the correct answer of 'no visible change'. Both sulfite and carbonate ions will form a white precipitate in this test if the nitric acid is omitted. The use of nitric acid ensures that only sulfate ions will result in the formation of a white precipitate.

Question 4

Some excellent and succinct descriptions of this preparation were seen, with a good proportion of candidates gaining full credit.

This planning task was a qualitative preparation of cobalt(II) sulfate. As it was a qualitative task, there was no need to measure volumes of masses.

Good responses included the following points:
- add an excess of cobalt(II) oxide to dilute sulfuric acid in a suitable container such as a conical flask
- heat and stir the mixture
- filter the mixture to remove excess cobalt(II) oxide
- evaporate the filtrate by heating to the point of crystallisation
- cool the solution and isolate the dry crystals by filtration or drying the crystals with filter paper.

The most common errors were omissions. Many candidates did not specify that the base should be in excess (although the best candidates explained why it should be in excess), some did not mention any container to carry out the reaction in and some specified an unsuitable container such as a measuring cylinder. Some candidates specified that cold acid should be used and that it would need leaving a long time because the reaction was slow rather than using warmed sulfuric acid.

A small but significant minority of candidates missed out entirely the stages in which cobalt(II) sulfate solution was made and instead chose to start with cobalt(II) sulfate solution.

It should be noted that there is no need for candidates to write a list of aims and apparatus at the start of their answers. The aim of the plan is in the question and credit will not be given for listing items of apparatus; where credit is available for the selection of an appropriate item of apparatus then it must be clear in the plan for what the item of apparatus will be used.

CHEMISTRY

Paper 0971/62
Paper 6 Alternative to Practical

Key messages

- When plotting graphs, points should be plotted as a cross (x) or an encircled dot (⊙) and not obscured by the graph line, which should be drawn using a sharp pencil. Lines of best fit should be smooth curves or ruler-drawn straight lines; they should not wobble from point to point. Candidates will need to decide if the points lie on a straight line or a curve.
- In the qualitative analysis question (**Question 3**) where a question states, 'Any gas given off is tested', then candidates are expected to record the details for the gas test that gives a positive result. Candidates are expected to use the term 'precipitate' when describing the formation of a solid from the reaction between two solutions; if when two solutions are mixed the product becomes cloudy and opaque, then a precipitate has been formed.
- 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 will not be awarded.
- In qualitative analysis, not all of the tests described will necessarily give a positive result; a negative test result is useful since it informs that a certain ion is **not** in the compound being tested.
- To state that a gas is given off is **not** an observation. The relevant observation would be effervescence or fizzing or bubbles (of a gas).

General comments

The vast majority of candidates successfully attempted all of the questions and were able to complete all questions in the time available. The paper was generally well answered, with very few blank spaces.

When answering the planning question (**Question 4**), there is no need for candidates to write a list of apparatus at the start, nor the aims of the experiment, nor a list of safety precautions. Where there is credit available for the use of suitable apparatus, then this will only be awarded if it is stated what the apparatus is used for; this will not be awarded just for a name in a list of other apparatus.

Comments on specific questions

Question 1

(a) The vast majority of candidates correctly identified the apparatus as a beaker, although trough and ice bath were also acceptable.

(b) Most could place the 'heat' arrow in the correct place, although a few heated the ice bath.

(c) This proved to be challenging. The expected answer was that steam has been cooled down by the ice bath and condensed to water, which many candidates correctly answered. However, a significant minority incorrectly thought that it was the lead (or lead(II) oxide or methane) that was collected here.

(d) A large proportion of answers correctly suggested that there was increased surface area and therefore a faster reaction.

(e) The expected answer was that methane is a flammable gas. However, a more common answer was that it is a toxic gas, which is incorrect.

Question 2

(a) The vast majority of candidates successfully completed the table with all five times and all five temperatures. The most common error was to not record all temperatures to one decimal place, such as 27 rather than 27.0 °C. A few also recorded time in minutes and seconds rather than just seconds.

(b) The vast majority of candidates were able to select an appropriate scale and plot the five points accurately. Some candidates selected a scale that made the plotting of results difficult. When drawing a line of best fit candidates should remember that a best-fit line should be a single, thin, smooth straight-line or curve and that the line does not need to coincide exactly with any of the points; where there is scatter evident in the data, a roughly even distribution of points either side of the line over its entire length is expected.

(c) Almost all candidates were able to identify Experiment 5 as having the fastest rate of reaction. A small minority just said that it was the experiment with the highest temperature but did not say which experiment that was.

(d) Most candidates gained full credit here. Ideally, the appropriate working on the graph was shown as a horizontal line starting at 55 seconds and going to the graph line and then down to the *x*-axis where the reading was taken. This working was missing in a number of responses.

(e) Most candidates realised that cotton wool would act as an insulator, but many of those who stated this did not then go on to say this would result in the temperature of the reaction mixture remaining more constant. A common error was to state the temperature would be more accurate, this is incorrect as the accuracy of the temperature recorded at the end of the experiment is a function of the thermometer used. Some candidates confused this reaction with mass loss from the reaction of calcium carbonate with an acid and stated the cotton wool would let gases escape.

(f) (i) The vast majority of candidates correctly referred to the improved accuracy of a burette compared to a measuring cylinder.

(ii) The problem with using a pipette in this investigation is the slow rate at which the liquid runs out of a pipette which would mean the reaction would start some time before all of the aqueous sodium thiosulfate had been added. Stronger responses explained this problem very clearly. A common incorrect answer was to state that 'pipettes only measure a fixed volume' – that is not an issue in this investigation as the volume of aqueous sodium thiosulfate is fixed at 5 cm^3.

(g) Better responses correctly stated that the reaction would be occurring while the reaction mixture was being heated.

(h) Many candidates stated that the rate of reaction would be unchanged and gave a correct reason for this in terms of solution concentrations or temperature. However, the question was not asking about the rate of the reaction, the question asked about how the results would change. The result being measured, the dependent variable, was the time taken for the text to become visible. As a larger beaker would result in a shallower depth of solution in the beaker, the text would become visible more quickly as it is being obscured by a lesser depth of solution.

Question 3

(a) It was evident that many candidates were not familiar with conducting a flame test. About half the answers had the idea of using a wire (usually made of nichrome or platinum) or a (wet) splint. Very few went on to use the wire to introduce the sample into a hot/blue/roaring flame.

(b) Most candidates correctly stated that the gas produced was ammonia.

(c) Nearly all candidates gained credit for identifying the cation present, but a significant few went on to identify the anion as ammonium.

(d) About half correctly noted the formation of a white precipitate; others suggested fizzing or that there was no change.

(e) The expected observations were that there was effervescence (or fizzing or bubbling) and that, when tested, the gas made turned limewater milky. While many correct observations were seen, many candidates stated that a gas was given off, which is not an observation. Others did not give the limewater test or did not give the result of the test.

(f) Most candidates correctly reported the formation of an insoluble green precipitate.

Question 4

This extended planning question was well answered with many candidates getting full credit. Candidates made good use of the data provided.

This was a quantitative task and so candidates had to ensure that appropriate measurements were made and included in their plans.

The vast majority of candidates used a method based on mixing with water to remove ethanoic acid and propanol followed by using dilute nitric acid to react with the iron(III) oxide. The first step using water is not required as the information in Table 4.1 states that ethanoic acid and propanol both dissolve in dilute nitric acid.

Good responses included the following steps in the plan:
- Add a known mass of metal polish to dilute nitric acid in a beaker or conical flask and heat the mixture.
- Filter the mixture to isolate the unreacted silicon(IV) oxide.
- Wash and dry the silicon(IV) oxide residue.
- Find the mass of the residue.
- Calculate the percentage by mass by dividing the mass of the residue by the mass of the polish and multiplying the result by 100.

Many excellent and succinct answers were seen. However, a common reason for candidates not obtaining full credit was the omission of details. Some candidates did not specify a suitable container in which to carry out the reaction or used an unsuitable container such as a measuring cylinder. Another common error was omitting the important stage of drying the silicon(IV) oxide after filtration. Some candidates mixed up the terms ‘residue’ and ‘filtrate’ and so described process carried out on the wrong part of the mixture.

Candidates would be well advised to plan the investigation before beginning to write their response.

A small minority of candidates used the individual components of the metal polish rather than investigated a sample of the metal polish.

It should be noted that there is no need for candidates to write a list of aims and apparatus at the start of their answers. The aim of the plan is in the question and credit will not be given for listing items of apparatus; where credit is available for the selection of an appropriate item of apparatus, then it must be clear in the plan for what the item of apparatus will be used. Writing a list of dependent, independent and control variables is also not necessary.