CHEMISTRY

Paper 5070/11
Multiple Choice

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

General comments

The paper consisted of 40 questions that involved choosing the correct answer from four alternatives. Candidates found the following questions the most accessible: **1**, **6**, **7**, **9**, **13**, **17**, **23**, **28–32**, **36**, **39** and **40**.

Questions that candidates found more challenging are analysed in further detail below.

Comments on specific questions

The choice of options in the following items revealed where some candidates had gaps in their knowledge and/or misconceptions.

Question 2

Many candidates chose options **B** and **D**, showing they were unsure how to identify aluminium, calcium and zinc ions.

Question 3

All of the options were chosen. This showed weak understanding of the arrangement and distribution of elements in the air.

Question 4

Option **C** was chosen by many candidates. This suggests that they thought mass loss is not a valid method for following gas formation.

Question 5

A significant proportion of candidates chose incorrect options. This indicates a weak understanding of the relationship between volume, temperature and pressure in gases.

Question 8

Many candidates chose option **C**. This shows that they thought ionic compounds share electrons.

Question 10

Option **C** was frequently selected. These candidates did not appreciate that chlorine exists as diatomic molecules.

Question 15

Many candidates chose option **C**. This was the answer if inert graphite electrodes had been used rather than copper.

Question 17

A significant proportion of candidates chose the options with a negative value as the activation energy.

Question 18

A significant proportion of candidates chose incorrect options. This shows a weakness in linking bond breaking to endothermic processes.

Question 19

Many candidates thought that a catalyst could shift the position of equilibrium.

Question 21

Many candidates chose option **B**, missing the more general definition of oxidation given by the key, **A**.

Question 22

A significant proportion of candidates chose options **A** and **D**. This showed insufficient understanding of ammonia chemistry.

Question 25

Option **C** was selected frequently. The misconception was that increased plant growth leads directly to reduced oxygen levels.

Question 26

Many candidates chose option **B**.

Question 27

Many candidates chose options **A** and **C**. Candidates may have had insufficient subject knowledge.

Question 33

Option **A** was selected more often than the key. More candidates thought that carbon rather than chlorine is responsible for ozone depletion.

Question 34

Many candidates chose option **B**. This indicates weak subject knowledge of desalination.

Question 38

Many candidates chose option **B**, i.e. methyl propanoate rather than propyl methanoate as the name of the ester.

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Paper 5070/12
Multiple Choice

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

General comments

The paper consisted of 40 questions that involved choosing the correct answer from four alternatives. Candidates found the following questions the most accessible: **1**, **6**, **7**, **8**, **13**, **16**, **18**, **23**, **27**, **29**, **30**, **32** and **39**.

Questions that candidates found more challenging are analysed in further detail below.

Comments on specific questions

The choice of distractor in the following items revealed where some candidates had gaps in their knowledge and/or misconceptions.

Question 2

Many candidates chose **B** or **D**, showing they were unsure how to identify aluminium, calcium and zinc ions.

Question 3

All of the options were chosen. This showed weak understanding of the arrangement and distribution of elements in the air.

Question 4

Option **C** was chosen by many candidates. This suggests that they thought mass loss is not a valid method for following gas formation.

Question 5

Many candidates chose option **A**. This suggests a misconception about the movement of spots up the chromatogram.

Question 14

All three incorrect options were chosen by candidates.

Question 15

Option **D** was chosen by many candidates, suggesting weak knowledge of the reactivity series.

Question 19

A significant proportion of candidates chose incorrect options. This shows a difficulty in linking bond breaking to endothermic processes.

Question 20

Many candidates thought that a catalyst could shift the position of equilibrium.

Question 21

A significant proportion of candidates chose incorrect options. Candidates found it difficult to work out that the same volume of hydrogen would be produced and/or that a higher acid concentration gives a steeper curve.

Question 22

All three incorrect options were chosen widely by candidates.

Question 24

A significant proportion of candidates chose option **A**. This showed that candidates thought that copper metal reacts with dilute acid.

Question 25

Option **D** was frequently chosen.

Question 26

Many candidates chose option **A** and thought barium chloride is insoluble.

Question 28

Option **A** was chosen frequently. The misconception is that all noble gases have eight electrons in their outer shell.

Question 33

Options **A** and **C** were frequently chosen. More candidates thought that carbon or fluorine, rather than chlorine, is responsible for ozone depletion.

Question 34

Many candidates thought that hydrogen or water vapour formed 1% of dry air.

Question 36

Many candidates did not recognise the loss of two hydrogens when butanol is oxidised to butanoic acid.

Question 40

Many candidates chose options **A** and **B**. This shows weak knowledge of polymer chemistry.

CHEMISTRY

Paper 5070/21
Theory

Key messages

Candidates need to show all relevant working out when completing calculations so that error carried forward marks can be awarded.

Candidates must distinguish between rate of reaction and position of equilibrium when answering questions.

Questions involving the structure and bonding were found to be challenging. Candidates should ensure that the answer refers to the correct specified particle for the question e.g. ions for ionic compounds and molecules for simple molecular compounds, cations and electrons for metallic bonding

General comments

Candidates appeared to have sufficient time to complete all the examination paper.

Most candidates answered only three questions from ***section B*** and required, but a small proportion of candidates answered all four.

Comments on specific questions

Section A

Question A1

This was an objective question about elements.

(a) (i) Candidates often chose krypton; nitrogen was a popular incorrect answer.

(ii) Many candidates appreciated that nitrogen was 78% of dry air and only a small proportion of the candidates gave oxygen as the answer.

(iii) Some candidates appreciated that calcium oxide reacts with impurities in the blast furnace to make slag. Copper and sulfur oxides were common incorrect answers.

(iv) Many candidates recognised that copper(II) ions react with aqueous ammonia to give a dark blue solution.

(v) Many candidates appreciated that chlorine reacts with propane. The most popular incorrect answer was oxygen.

(b) A significant proportion of the candidates were able to give the correct numbers of all subatomic particles. Candidates found the magnesium ion more demanding than the sulfur atom and often did not consider the charge on the ion when working out the number of electrons, Other candidates gave 15 neutrons rather than 13 neutrons in the magnesium ion.

Question A2

This question focused on the electrolysis of aqueous copper(II) sulfate.

(a) Candidates often misinterpreted the question and gave the arrangement as closely packed or not moving, or described the particles present. Only a small number of candidates mentioned the idea of a lattice and these candidates were more likely to describe it as a pattern or an ordered arrangement. Candidates rarely mentioned electrostatic attraction and often referred to ionic bonding or the attraction between positive and negative ions.

(b) Many candidates referred to the presence or lack of free ions without giving any indication of the ions being either mobile or immobile. A common misconception was to refer to the presence of delocalised or moving electrons in aqueous magnesium chloride and the lack of moving electrons in solid magnesium chloride.

(c) (i) The best answers referred to the ionisation of water; many answers just stated the water in the aqueous solution. Some candidates thought the hydroxide ions came from the sulfate ions or from hydrogen and oxygen.

(ii) Some candidates did not appreciate the importance of having the electrons on the right-hand side of the equation and included other formulae of other ions such as sulfate or copper(II).

(iii) Candidates found this question quite challenging and often just repeated the information in the stem of the question. Other candidates referred to the differences in concentration of the two ions. The best answers compared the reactivity of the two ions involved.

(d) (i) Some candidates could give all four formulae; other candidates often got the formula for the sulfate ion incorrect or gave O^{2-} rather than OH^{-}. Common misconceptions included writing some form of equation or giving the formulae of other substances.

(ii) A significant proportion of the candidates did not attempt this question. Some candidates appreciated that sulfuric acid was formed; only the best answers appreciated that the hydroxide ions were discharged leaving the hydrogen ions in the electrolyte.

(iii) Candidates often appreciated that the blue colour was linked to copper; they rarely referred to the copper(II) ions. Candidates often referred to the copper(II) ions being reduced or being discharged. A common misconception was that copper rather than copper(II) ion was discharged.

(e) Many candidates could recall the 'dot-and-cross' diagram for an oxygen molecule.

Question A3

This question was about the structure of metals and the extraction of metals.

(a) (i) Candidates often suggested that atoms could slide over each; they rarely described the layers of ions sliding.

(ii) Many candidates appreciated that the electrons shown in the diagram were either mobile or delocalised. Responses that just mentioned that metals have free electrons were not given credit since there was not enough in the answer to suggest the electrons were moving.

(b) Candidates found this question very challenging. Some candidates listed the oxides rather than the metals and many candidates had titanium as the least reactive metal.

(c) (i) The best answers showed all the correct steps and gave the correct answer of 10.1 g. Some candidates gave an answer of 10.08 g, which was not to three significant figures. A common misconception was to use the mass given as though it was the amount in moles. Typically, answers using this misconception gave an answer of 28.8 g.

(ii) A significant proportion of the candidates did not attempt this question. Candidates often understood that the volume = amount in moles $\times$ 24 dm^3; only a small proportion of the candidates could use the correct amount in moles. There was very little evidence of candidates using their answer to part **(i)** as the starting point for this calculation.

Question A4

This question focused on the chemistry of malic and fumaric acid.

(a) The name of the –OH group was well known and typically candidates gave answers of alkanol or alcohol.

(b) A significant proportion of the candidates did not attempt this question. Candidates found this question very challenging and rarely appreciated that the reagent needed to be propanol. The mark for the conditions was conditional on the correct reagent or the appreciation that an alcohol had to be used. Candidates often struggled with giving the correct conditions. Marks were awarded for the use of an acid catalyst, such as sulfuric acid or the idea that the reaction mixture had to be heated.

(c) Candidates often performed well on this question; a common misconception was that malic acid decolourised bromine and fumaric acid did not.

(d) (i) The two types of polymerisation were well known; some candidates referred to additional or condensational polymerisation and these were not given credit.

(ii) A significant proportion of the candidates did not attempt this question. Most candidates who attempted the question drew the addition polymer. Better responses drew two or more whole repeat units and a continuation bond at either end. Many candidates were imprecise with the connections between the carbon chain and the -COOH and -OH group. A common misconception was to draw one repeat unit surrounded by a bracket (often with ether n or 2 as a subscript). This was not sufficient, since it did not clearly show two repeat units.

Question A5

This question focused on hydrocarbons.

(a) Many candidates could construct the equation. Some candidates gave an equation with a fraction and if balanced this was given full credit. A small proportion of the candidates gave the correct products but could not balance the number of oxygen molecules. The most common misconception was to give an equation with carbon dioxide, water and a hydrocarbon as the products.

(b) Many candidates gave contradictory answers either involving bond making absorbing energy or bond breaking releasing energy. The best answers just stated more energy released in bond forming than absorbed in bond breaking.

(c) The most popular uses given was as a fuel for cooking, jet engines and lamps. Candidates must ensure they give sufficient detail for the use; for example, used in planes was not sufficient.

Section B

Question B6

This question focused on the homologous series of carboxylic acids.

(a) Many candidates appreciated that a weak acid only partially dissociates; the majority of candidates forgot to mention the formation of hydrogen ions. A common misconception was to refer to weak acids having a relatively high pH value.

(b) (i) Candidates found this question challenging and often referred to rate of reaction to explain their answer. Many candidates predicted that the position of equilibrium moves to the right; only a very small proportion of the candidates appreciated this was to reduce the concentration of ethanol.

(ii) Candidates found this question less challenging than part **(ii)** but a significant proportion of the candidates used ideas about rate of reaction to explain their answer. Answers were often not sufficiently precise, and it was not possible to tell if the reference to endothermic reaction was to the backward reaction or the forward reaction.

(c) (i) Candidates found this data interpretation question straight forward. Some candidates tried to explain the trend, but this was not asked for in the question.

(ii) Candidates found this data interpretation question straight forward and typically gave answers with three significant figures within the range accepted in the mark scheme.

(iii) Candidates often found this question challenging, in terms of giving a precise explanation. Some candidates gave the correct state but just quoted the melting and boiling point data as the explanation. The best answers appreciated that 15 °C was a lower temperature than the melting point.

(iv) Some candidates appreciated there was no trend shown in the data; others gave very imprecise answers about a lack of constant increase or decrease.

(v) Candidates often did not draw all the bonds between atoms and wrote -OH rather than -O—H. Some candidates confused propanoic acid with pentanoic acid.

Question B7

This question focused on the elements in Group IV of the Periodic Table.

(a) (i) Candidates often referred to the bonds needing lots of energy to break but forgot to mention that the structure was giant. A common misconception was to refer to strong intermolecular forces, or the presence of molecules in diamond.

(ii) Candidates found this question challenging. The structure and bonding in tin was not well known and many candidates referred to molecules and weak intermolecular forces. Candidates also did not use the data in the table to explain their answer; for example, referring to the presence of delocalised electrons and electrical conductivity.

(iii) The meaning of amphoteric oxide was well known with candidates often referring to oxides having both acidic and basic properties.

(b) (i) Some candidates were able to deduce the formula as $GeCl_4$. Many candidates could not interpret the information given and used the incorrect masses of germanium and chlorine in their answer. A small proportion of the candidates used atomic number rather than relative atomic mass in their calculations. Better performing candidates used a tabulated method of working out, which enabled the award of error carried forward marks. A small proportion of candidates calculated the percentage composition and used these figures to deduce the empirical formula.

(ii) Candidates found this question quite demanding and often referred to giant structures and ionic bonds. Only a small proportion of the candidates were able to deduce that $GeCl_4$ was a simple molecular structure with covalent bonding.

Question B8

This question focused on fertilisers and ammonia.

(a) Many candidates were able to calculate the percentage of nitrogen to be 28.2%. Candidates were given credit for any correct answer, which had at least two significant figures. A small but significant proportion of the candidates were unable to calculate the molar mass for ammonium phosphate.

(b) A number of possible correct answers were seen, including improving soil fertility and increasing crop yield. Some candidates did not give sufficient detail and only mentioned that nitrogen was needed for growth.

(c) Many candidates could recall the test for ammonia. Some candidates described the test for ammonium ions, which also included the test for ammonia.

(d) A significant proportion of the candidates did not attempt this question. Candidates often appreciated that ammonia gas was produced. A common misconception was that nitrogen was produced in the reaction between calcium hydroxide and ammonium phosphate

(e) Some candidates misinterpreted the information in the stem and used the volume of ammonia with the concentration of sulfuric acid. Other candidates did not use the correct mole ratio. The best answers calculated the moles of sulfuric acid, the moles of ammonia and finally the concentration of ammonia as $0.158\,mol/dm^3$.

Question B9

This question focused on rate of reaction and the chemistry of propene. This was the least popular of all the questions in ***section B***.

(a) Many candidates were able to explain that both compounds had the same molecular formula but different structural formulae. Some candidates only mentioned the same molecular formula and neglected to include the different structures. Other candidates referred to the same formula without indicating what type of formula was involved.

(b) Candidates found this question challenging and often described how the concentration of propene changed with increasing time. These candidates did not appreciate that it was about the change in rate of reaction with increasing time that had to be described. Only a very small proportion of the candidates referred to the gradient of the line.

(c) Many candidates did not mention either particles or collisions in their answers and often gave explanations related to equilibria rather than rate of reaction. Only a small proportion of the candidates referred to an increased collision frequency and an even smaller proportion referred to an increase in the number of particles per unit volume.

(d) Some candidates gave an answer more related to equilibria; most candidates attempted to give a collision theory answer. Only a small proportion of candidates confused the explanation for temperature with that for concentration. Often candidates made errors of omission rather than being incorrect e.g. having more energy rather than particles having more kinetic energy or having more collisions rather than more successful collisions.

(e) Candidates found this question challenging. Some candidates appreciated that propanol was made in the reaction with steam; the structure given was often incorrect. The conditions for hydrogenation was not well known and often the conditions for other catalysed reactions were given e.g. for the hydration of propene.

CHEMISTRY

Paper 5070/22
Theory

Key messages

Candidates need to read the stem of each question carefully and take notice of the information provided.

Some candidates need more practice in the handling of information provided in tables of data.

Many candidates need more practice in writing about structure, bonding and the particulate nature of matter.

General comments

Many candidates were well able to interpret the information provided in the stem of the question or in tables of data. Others often did not appear to read the stem of the question carefully enough. For example, in **A1(a)(v)** many candidates did not take sufficient notice of the white precipitate; in **A5(a)** many candidates did not take notice of the formula given for sodium ethanoate; in **B8(e)** many candidates muddled the volumes of the acid and alkali. Some need more practice in the handling the information given. For example, in **A3(b)** many candidates appeared to rely on their existing knowledge of the reactivity series instead of interpreting the data in the table. In **B6(d)(ii)** and **B6(d)(iii)** many candidates did not refer to the values provided or had difficulty with the negative values. In **B9(b)(ii)** many did not appear to refer to the equations given and gave answers which were independent of these equations.

Some candidates' knowledge of structure and bonding was good. In **B7(a)** and **B7(b)** many could not distinguish between simple molecular structures, giant covalent structures and metallic structures, often referring to metallic structures as being molecular, covalent or ionic. In addition some candidates referred to intermolecular forces in a metallic structure. Many candidates did not realise that the low melting point of molecular structures are due to weak forces between the molecules (not between the atoms). In **A2(a)** many candidates did not appear to know the meaning of the word 'arrangement' with reference to the ions present in solid magnesium chloride.

The writing of balanced equations was not always successful, a major obstacle for some candidates being to work out how to construct ionic equations. **A2(d)(ii)** caused particular problems in terms of both identifying the species involved and balancing the equation. In **A5(a)** many candidates need more practice in balancing equations involving the reactions of carboxylic acids.

Practical aspects of chemistry as in **A4(c)** on chromatography, pose a challenge for some candidates. For example, many candidates suggested that the dye be placed in the solvent. Many candidates also need more revision on qualitative tests such as seen in **A2(d)(iii)** and **B8(b)**.

Most candidates need practice in drawing a section of a condensation polymer chain from a given monomer (**A4(d)**) and in writing the molecular formula of an organic compound (**A4(a)(i)**).

Some candidates performed well in questions involving calculations, showing appropriate working, clear progression in each step of the calculation and clear indications about what each number refers to. In questions involving the calculation of an empirical formula (**B7(b)(i)**) candidates need to set out their working clearly, preferably in tabular form.

Comments on specific questions

Section A

Question A1

Most candidates scored well. The exception was in **(a)(iii)** where many selected carbon rather than hydrogen as a product of cracking hydrocarbons.

(a) (i) Most candidates identified iron as the catalyst in the Haber process. The commonest incorrect answer was vanadium.

(ii) Most candidates realised that oxygen makes up 21 per cent of dry air. The commonest incorrect answer was to suggest nitrogen and a significant minority suggested hydrogen.

(iii) Many candidates recognised that hydrogen is a possible product of cracking hydrocarbons but a significant number of candidates suggested carbon.

(iv) A large majority of the candidates identified aluminium. Some candidates did not note the statement about the white precipitate in the question and gave incorrect answers such as iron or vanadium.

(v) Most candidates suggested aluminium. A wide variety of incorrect answers was seen, the commonest being nitrogen, possibly because the nitride ion has a 3– charge or because of the presence of three electrons in the outer subshell.

(b) Many candidates deduced all four numbers correctly. The commonest error was to ignore the charge on the O^{2-} ion and give the answer as eight electrons instead of 10. Other candidates gave reversed numbers for electrons and neutrons, e.g. 22 electrons and 19 neutrons for ^{41}K.

Question A2

This question was fairly well answered. The exceptions were in **(a)** where many misunderstood the term arrangement (of ions), **(d)(i)** where many candidates compared the reactivity of the ions rather than the elements and **(e)(ii)** where few were able to explain why the solution becomes more alkaline as electrolysis proceeds.

(a) Candidates often misinterpreted the question and gave the arrangement as closely packed or not moving, or described the type of particles present. Only a small number of candidates mentioned the idea of a lattice pattern or ordered arrangement. A minority of candidates referred to the type of forces being electrostatic. The commonest responses for this second marking point were either to refer to ionic bonding or to the attraction between positive and negative ions, neither of which were sufficient to gain the mark.

(b) Many candidates referred to the presence or lack of free ions without giving any indication of the ions being mobile or immobile. A few suggested that the ions were delocalised, a term which should be more properly used for electrons rather than ions. A few did not specify the state of the magnesium chloride in their answers or referred to molten magnesium chloride rather than aqueous magnesium chloride. A common misconception was to refer to the presence of delocalised or moving electrons in aqueous magnesium chloride and the lack of mobile electrons in solid magnesium chloride.

(c) Many candidates gave the electronic structure of the atoms rather than the ions. A few candidates gave subshell notation in their answers, which was more often than not incorrect. A few just gave the formulae of the ions. A minority of candidates did not take note of the proton number to help them deduce the electronic configuration of the ions and gave structures with up to six shells of electrons.

(d) (i) Many candidates compared the reactivity of the ions rather than the elements. Others referred to preferential discharge or suggested that 'it is easier to discharge hydrogen ions than sodium ions' without giving any further explanation. Few candidates compared the ability of ions to gain electrons or the ability of the ions to be reduced. Some candidates just referred to the hydrogen ions moving to the negative electrode but offered no further information.

(ii) Some candidates wrote a correctly balanced equation. Common errors included not balancing the hydrogen ions, putting + $2e^-$ on the right hand side of the equation and writing the formula of hydrogen as H instead of H_2. Some candidates gave the equation for the discharge of chloride ions rather than hydrogen ions, or added extra ions. Other errors included reversing the equation and a lack of charge on the hydrogen ion.

(iii) Many candidates appreciated that litmus paper could be used to test for chlorine but some candidates gave the final colour of the litmus as blue or suggested that it turns blue and then bleaches. A significant number of candidates gave the test for chloride ions, with silver nitrate and dilute nitric acid as the test reagents. A small number of candidates suggested using potassium iodide. This was unacceptable as an answer because it is not specific enough for chlorine.

(e) (i) A majority of the candidates gave the correct formulae for all four ions. Common errors included O^{2-}, Cl^{2-}, Cl^{2-} and Na^{2+}. Some candidates gave $NaCl$ and/or H_2O instead of ionic formulae. A small number of candidates wrote equations but these were often not appropriate in the context of the question.

(ii) A minority of candidates appreciated that hydrogen ions were discharged and that the hydroxide ions remained. Many candidates suggested, incorrectly, that hydroxide ions were also discharged. A greater number of candidates scored the second marking point by noting that sodium hydroxide was present. A few candidates referred to cost rather than focussing on the ions present in the solution.

Question A3

Many candidates gave good answers to the calculation in **(c)(i)**. Others need more practice in handling information relating to chemical reactivity (**(b)**) and in explaining the effects of pollutants on health (**(d)**)

(a) Most candidates gave two suitable physical properties. The commonest correct answers were malleable, ductile and high melting and boiling points. A minority of candidates gave chemical properties instead of physical properties.

(b) A minority of candidates gave the correct order of reactivity using the data in the table. Sodium was often given as the most reactive but candidates appeared not to use the information given to establish the order of reactivity of the other elements. Many examples were seen in the scripts where candidates wrote out a remembered sequence of reactivity. Candidates should be advised that this type of question is about handling the information given and not about recall of the reactivity series.

(c) (i) Many answers were seen that showed all the correct steps in the working and the answer to three significant figures. A small minority of candidates did not follow the instruction about the number of significant figures required in the answer. The commonest error was to forget to divide the number of moles of Fe_3O_4 by three. Other common errors included assuming that one mole of iron reacts to give three moles of Fe_3O_4 and working out moles of iron using the molar mass of Fe_3O_4. A small proportion of candidates did not use a mole approach but used a ratio method starting with 168 g iron being obtained from 232 g of Fe_3O_4 and then using the correct ratio to work out the correct mass of iron. This was given due credit.

(ii) Although the idea of volume = moles · molar mass was quite well known, most candidates did not use the correct number of moles. There was little evidence of candidates using their answer from **(c)(i)** and most candidates started the calculation all over again. The commonest misconception was to use four moles of hydrogen which appears in the stoichiometric equation. A small proportion of candidates used 24 000 cm^3 instead of 24 dm^3 as the molar gas volume but did not change this on the answer line, where dm^3 was the given unit.

(d) Some candidates appreciated the toxic or poisonous nature of carbon monoxide. Others just stated that the gas is harmful or dangerous without going on to explain the effect on humans. Common answers not gaining credit were that 'the reaction is hot' or 'the gas is flammable'.

Question A4

This question was generally well answered except for **(a)** where few candidates knew what was meant by the term molecular formula and **(d)** where few candidates were able to draw a suitable section of the polymer.

(a) (i) Few candidates gave the correct molecular formula. Many answers gave some form of structure or gave a formula in which one of the elements was missing or another element was added. Some candidates gave the answer $C_{10}H_{17}OH$ and did not appreciate that this is not a molecular formula.

(ii) Most candidates identified the alcohol functional group correctly. The commonest errors were to give specific examples e.g. ethanol or to suggest 'an –ol'.

(b) The bromine water test for unsaturation was fairly well known. Some candidates suggested that the 'bromine water stays orange' and a few did not gain the mark because they gave inexact answers such as 'discolours' or 'goes clear'. A small proportion of candidates gave potassium permanganate as the test reagent but gave the incorrect colour change.

(c) Diagrams were often unlabelled and it was often difficult to tell the nature of the liquid used or what the dots represented. Only the best candidates defined what is meant by R_f. If a named solvent was used it was often water. Many candidates labelled the pencil base line incorrectly 'solvent front'. Diagrams often did not include the solvent and only had a piece of chromatography paper in a beaker. Many candidates did not access the first two marks because they placed the dye in the solvent or suggested that the solvent was 'the solution'. The latter was not given credit because the stem of the question states explicitly that there is a 'solution of the coloured compounds'. Many candidates mentioned a locating agent without going on to suggest how the R_f should be calculated.

(d) A few candidates were able to draw repeat units and of these candidates, most included the continuation bonds. Many candidates did not realise that an amide link would be formed and an oxygen atom was often included in the linkage, e.g. NHOCO. Ester linkages were also seen. Many candidates drew two separate structures which were not linked in any way. These were often just the monomers with or without brackets. A small proportion of candidates drew nylon 6,6 or drew a type of addition polymer with COO side chains.

Question A5

In **(a)** very few candidates could write the equation for the reaction of ethanoic acid with sodium carbonate correctly. In **(b)** the explanation in terms of bond making and bond breaking was poorly explained and many answers were contradictory.

(a) Few candidates performed well on this part. The commonest error was the incorrect formula of sodium carbonate, usually written as $NaCO_3$. Other candidates gave the formula for propanoic acid rather than ethanoic acid or wrote the reaction for sodium with ethanoic acid. Others gave one of the products as hydrogen instead of water.

(b) Many candidates gave answers which were contradictory and either referred to bond making and bond forming as both needing energy, both absorbing energy or both releasing energy. Many wrote bond breaking is endothermic and bond forming is exothermic then contradicted this in their explanation by writing incorrect statements such as 'the energy needed to break the bonds is greater than the energy <u>needed</u> to form the bonds'.

(c) Many candidates selected 'perfume' or 'flavouring' as a correct answer. A wide variety of incorrect or vague answers were seen, e.g. 'preserving food', 'plastic bags', 'making wine'.

Section B

Question B6

Some candidates gave good answers to many parts of this question especially to **(d)(i)**. In **(b)(i)** many candidates omitted to define acid as part of the term 'strong acid'. In **(d)(ii)** and **(d)(iii)** a significant number of candidates did not give precise enough answers to gain credit.

(a) (i) Some candidates gave good answers in terms of the equality of the number of moles on each side of the stoichiometric equation. The idea that the reaction moves to the side with the fewer number of moles was often well expressed but many candidates were not able to use this idea to predict that the position of equilibrium would remain unchanged. Many predicted, incorrectly, that the equilibrium would shift to the right, even though they recognised that there were an equal number of moles on each side of the equation. A small proportion of candidates referred to rate rather than equilibrium.

(ii) Some candidates gave good answers predicting that the equilibrium would move to the left to release heat to try and increase the temperature. A considerable number of candidates referred to rate rather than equilibrium. Many candidates gave answers that were not sufficiently precise. It was often not possible to tell if the reference to an exothermic reaction referred to the backward or the forward reaction. Candidates should be encouraged to write precise statements such as 'because the <u>forward</u> reaction is endothermic' or 'because the <u>backward</u> reaction is exothermic'.

(b) (i) Many candidates appreciated that a strong acid dissociates completely but the majority did not mention the formation of hydrogen ions. A number of candidates referred to the ease of dissolving of the acid in water instead of the degree of dissociation.

(ii) Some candidates constructed the correct equation. Others wrote the formulae of the elements H_2 and I_2 as either reactants or products. When ions were written, candidates normally wrote the correct formulae. The commonest error in writing the formula for the ions was I^{2-}.

(c) A minority of the candidates identified the reaction as an addition reaction. A large variety of incorrect reaction types were given. Common errors included polymerisation, hydrogenation and halogenation. A considerable number of candidates suggested exothermic or endothermic.

(d) (i) Most candidates interpreted the information in the table correctly. The commonest errors were either to reverse the trend or to explain the trend rather than describing the trend.

(ii) Some candidates gave good answers which referred to –7°C as being above the melting point but below the boiling point. Many candidates who gave liquid as the correct answer were not able to give an adequate explanation to include the –7°C. Some candidates appeared confused by the use of the negative values and suggested a solid or gaseous state for the butene. A considerable number of candidates referred to only one of the fixed points (melting point or boiling point).

(iii) Many candidates wrote vague statements about the data. The best answers just referred to the 'values decreasing and then increasing' or that there was 'no trend' or 'no pattern'. Many gave answers which were not based on the data but on other properties such as density or molecular mass.

Question B7

In **(a)** and **(b)** many candidates demonstrated a poor understanding of structure and bonding in relation to the properties of magnesium and sulfur and in explaining why silicon has a high melting point. Many candidates were able to deduce the empirical formula in **(c)(i)** but only a few were successful in deducing the molecular formula in **(c)(ii)**.

(a) (i) For magnesium, a majority of the candidates did not refer to the simple idea of a giant structure and many described the bonding in terms of intermolecular forces or covalent bonding. Candidates often referred to magnesium having molecules or an ionic structure (+ and – ions). Many candidates explained the low melting point of sulfur in terms of forces between atoms rather than molecules or wrote about weak covalent bonds. Many candidates wrote about strength of bonds with no reference to structure. Some candidates misread sulfur as silicon.

(ii) Many answers included incorrect ideas about bonding. The idea of the electrons being the charge carriers was often understood but many omitted the important words ‘motion’ or ‘movement’ (of electrons).

(b) Some candidates gave good answers referring to why diamond or silicon dioxide has high melting point. Some candidates gained credit for the idea that a lot of energy is needed to break the bonds. Many candidates made the error of referring to strong intermolecular forces or the presence of molecules of silicon.

(c) (i) Many candidates were able to deduce the empirical formula as SCl. Some candidates could not interpret the information given and gave incorrect masses for sulfur and chlorine and often incorrect relative atomic mass as well. Some candidates used atomic number rather than relative atomic mass in their calculations. Candidates who used a tabulated method in their working were able to clearly show their intermediate steps.

(ii) Only a small proportion of the candidates who were able to deduce the empirical formula as SCl in **(c)(i)** were able to deduce the molecular formula. Some made simple errors in addition of atomic masses. Many candidates did not appear to know how to proceed.

Question B8

Many candidates gave good answers to most parts. The calculation in **(a)** and **(e)** were generally well done with the working well set out.

(a) Many candidates completed the calculation correctly or obtained 22.4 for one mark. A few candidates used atomic number to work out the percentages.

(b) Many candidates chose the correct reagent and included the use of nitric acid. A few candidates did not obtain the first mark because they chose hydrochloric acid or sulfuric acid. Most of those who chose the correct reagent also referred to a white precipitate. The commonest errors were to suggest nitric acid alone as a test reagent, the use of litmus or the use of sodium hydroxide.

(c) Some candidates referred to nitrates dissolving or being soluble. Common errors were to write about the ease of absorption by plants, ease of travel through spaces in the soil or reference to small sizes of their molecules. A significant minority of the candidates wrote about chemical properties of nitrates or made comments about their melting points.

(d) Many candidates gave some information about eutrophication but often did not make their descriptions accurate enough. The idea of increased growth of algae/water plants was often omitted. A minority of candidates mentioned the role of aerobic bacteria helping to decompose algae. The idea that lack of oxygen caused life in the water to die was often poorly expressed. A common misconception was that it was the algae that caused the lack of oxygen rather than the aerobic bacteria.

(e) Many candidates completed this calculation successfully. A common error was to use the incorrect volumes (12.5 cm^3 for the phosphoric acid and 25 cm^3 for the potassium hydroxide). Some candidates were not able to convert volumes in dm^3 to cm^3. Others did not use the molar ratio given in the stoichiometric equation.

Question B9

Most parts of this question were well answered. The best answers were seen in **(a)** (how rate of reaction changes with concentration) and in **(c)(i)** (completion of an energy profile diagram). In **(a)(ii)** few candidates explained the answer with sufficient precision to obtain full credit. In **(b)(ii)** many did not refer to the information given when selecting a suitable property of the catalyst.

(a) (i) Most candidates were able to interpret the data but few gave a quantitative relationship such as doubling the concentration doubles the rate.

(ii) A few candidates gave an answer more related to equilibrium than to rate but most attempted to give a collision theory answer. Candidates often did not gain marks through errors of omission rather than giving an incorrect answer, e.g. 'more particles' instead of 'more particles <u>per unit volume'</u> or 'more collisions' instead of 'more frequent collisions'. A significant minority of the candidates disadvantaged themselves by referring to the particles having more energy when the concentration is greater.

(iii) Many candidates referred to increased kinetic energy and linked this to particles. However some omitted the essential word kinetic. Many referred to more collisions or more frequent collisions but did not qualify these by reference to the effectiveness or successful nature of the collisions. Few candidates referred to the idea of a greater number of particles having energy equal to or greater than the activation energy.

(b) (i) The commonest correct answer referred to volcanoes, with burning fossil fuels also a popular choice. A common error was to mention fossil fuels but omit burning or combustion. Other incorrect answers included 'acid rain' and 'contact process'. A number of candidates gave vague unqualified answers such as 'from factories' or 'from cars'.

(ii) Some candidates referred to the equations and deduced that the catalyst was reformed or was unchanged at the end of the reaction. Other candidates gave characteristics of catalysts which could not be deduced from the equations, e.g. 'lowers activation energy' or 'only a small amount of catalyst needed'. A common misconception was that a catalyst is unchanged during the reaction or that it does not take part in the reaction.

(c) (i) Many energy profile diagrams were completed correctly. Some candidates labelled their diagrams incorrectly, usually reversing the labels for the catalysed and uncatalysed reactions. Others did not label their diagrams. A few candidates did not draw the energy hump but drew a straight line between the energy levels or drew an energy dip.

(ii) Many candidates identified the reaction as exothermic but some gave imprecise explanations such as 'the reactant is lower than the product' without referring to the enthalpy or energy of the reactant or product.

CHEMISTRY

Paper 5070/31
Practical Test

Key messages

Success in this paper required a candidate to meet the practical and mathematical demands of a volumetric question. The examination’s qualitative tasks in the exam were centred on the tests given on the final page of the paper. Candidates competent in the experimental work and use of terminology associated with the qualitative analysis notes performed well.

General comments

Overall, candidates were able to complete the titration involved in **Question 1**; there was considerable variation in their ability to answer the related calculations.

The majority displayed competence with **Question 2**; there were some who were less secure in following the instructions and in providing accurate observations.

Comments on specific questions

Question 1

(a) The results table was generally properly completed. Concordant titres were usually selected; their accuracy was variable. Some candidates wasted valuable time by performing five or more titrations. Two concordant titres are sufficient.

Many candidates attempted all the calculations that followed and clear working was generally seen.

(b) A number struggled to calculate the concentration of nitric acid. The common errors found were associated with not using the mole ratio in the given equation and inverting the pipette and average titre volumes. Many answers were given to three significant figures but two and occasionally one were found.

(c) Very few candidates appreciated that $500\,cm^3$ of **P** had been prepared from $10.0\,cm^3$ of concentrated acid. As a result, many calculated the number of moles of H_2SO_4 in $10.0\,cm^3$ rather than in $500\,cm^3$ of the dilute acid.

(d) Many candidates multiplied their answer in **(c)** by 100. A comparison of the concentrations of the acid here and in **(b)** should have led some to review their previous calculation.

(e) Many realised that obtaining the answer to this question involved multiplying by 63; some ignored the instruction to use their answer from **(d)** and used another answer instead.

Question 2

All the points in the mark scheme were awarded in the assessment of the examination scripts.

There were several examples where correct observations were given but incorrect conclusions drawn.

In **test 2** numerous candidates did not appreciate that ammonia gas inevitably comes off the aqueous ammonia added. There were also some candidates who believed use of a boiling tube, in **test 2(c)**, meant that some heating was required. A boiling tube can be used because of its larger size rather than because of a requirement to heat.

Solution R

Test 1

There were a few who saw no precipitate at any stage, presumably because the alkali was added too quickly; the majority reported a white solid in **(a)** and generally found it dissolved in excess in **(b)**. The description of the final solution as colourless was not always included.

Test 2 (a) and (b)

A white precipitate, which dissolved in excess ammonia was reported by many; the description of the final solution was missed by some. There were a number whose solid remained in **(b)**, presumably because they did not agitate the mixture sufficiently.

Test 2 (c)

No reaction with hydrogen peroxide was reported by some; others provided observations indicating a gas being evolved, which was usually identified as ammonia. Any observations made as a result of heating the mixture were disregarded.

Test 3

Candidates frequently scored well in the **tests (a)–(c)**; there were a number who incorrectly used descriptions such as white or milky solution.

Solution S

Test 1

A green precipitate was generally seen in **(a)**; there were a few who believed it disappeared in excess alkali in **(b)**.

Test 2 (a) and (b)

The observations usually mirrored those in **test 1**.

Test 2 (c)

This proved to be the most challenging of the tests. More candidates noted the change in colour of the precipitate on addition of the hydrogen peroxide than noted the bubbling of the mixture. Whether they recorded effervescence of not, many identified an alkaline gas being produced but only the most careful candidates relit a glowing splint. The noisy relighting of a glowing splint occasionally led to hydrogen being named instead of oxygen by some.

Test 3

Candidates performed well in these tests; there were a number who incorrectly used descriptions such as white or milky solution.

Conclusions

Candidates often had sufficient evidence to identify correctly the compounds in **R** and **S** but did not secure the marks. Despite obtaining a white precipitate in **test 3(b)**, some concluded that the compound was a chloride. A significant number provided the names or formulae of the metal ions only. The other common error was to name **S** imprecisely as iron sulfate.

CHEMISTRY

Paper 5070/32
Practical Test

Key messages

Candidates should aim to read the examination paper thoroughly and so assimilate the information and instructions provided.

General comments

Most candidates possessed the necessary experience and competence to deal successfully with the demands of the examination. In **Question 1**, good titration technique was in evidence and many performed well on the volumetric based calculations. The qualitative tasks were centred on those tests given on the final page of the paper and many candidates made full use of the notes in constructing their observations.

Comments on specific questions

Question 1

(a) The titration results table was usually properly completed and many candidates produced accurate and concordant titres. There were some candidates who wasted valuable time by performing five or more titrations. Two concordant titres are sufficient.

Most candidates attempted all the calculations that followed and clear working was normally seen.

(b) The concentration of sulfuric acid in **P** was generally calculated correctly and the answer given to three significant figures.

(c) Very few candidates appreciated that 500 cm^3 of **P** had been prepared from 10.0 cm^3 of concentrated acid. Consequently, many calculated the number of moles of H_2SO_4 in 10.0 cm^3 rather than in 500 cm^3 of the dilute acid.

(d) Most candidates multiplied their answer in **(c)** by 100. A comparison of the concentration of the acid here with that in **(b)** should have led some candidates to review their previous calculation.

(e) Most candidates knew that obtaining the answer to this question involved multiplying by 98; many used a number other than that given in **(d)** or, having correctly calculated the value, went on to process it further often by dividing by 1000.

Question 2

All the points in the mark scheme were awarded in the assessment of the examination scripts. The ammonia gas that inevitably comes off aqueous ammonia caused problems in **test 2** for a significant number of candidates. There were also some candidates who believed use of a boiling tube, in **test 2(c)**, meant that some heating was required. A boiling tube can be used because of its larger size rather than because of a requirement to heat.

Solution R

Test 1

There were a few candidates who saw no precipitate at any stage, presumably because the alkali was added too quickly; the majority reported a white solid in **(a)** and generally found it dissolved in excess in **(b)**. The description of the final solution as colourless was not always included.

Test 2 (a) and (b)

A white precipitate, insoluble in excess was recorded by most candidates.

Test 2(c)

No reaction with hydrogen peroxide was reported by some; others provided observations indicating a gas being evolved, which was usually identified as ammonia. Any observations made as a result of heating the mixture were disregarded.

Test 3

Most candidates completed the tests **(a)**–**(c)** successfully.

Solution S

Test 1

Nearly all candidates reported a blue precipitate in **(a)**; there were a few who believed it disappeared in excess alkali in **(b)**.

Test 2 (a) and (b)

There were many candidates who observing a blue precipitate, which dissolved in excess ammonia to produce a darker blue solution; a significant number supplied confused or incomplete descriptions. In general, these appeared to be the product of poor technique e.g. 'a blue precipitate in a deep blue solution' – the result of poor mixing, or 'blue solution turns dark blue, no change with excess' – resulting from adding the ammonia too quickly.

Test 2(c)

This proved to be the most challenging of the tests. The more successful candidates noted the darkening of the solution on adding the hydrogen peroxide and the bubbling of the liquid. The identification of the gas proved problematic. Ammonia was frequently suggested and the noisy relighting of a glowing splint sometimes led to hydrogen being named instead of oxygen.

Test 3

There were many candidates who recorded the observations correctly for all the parts; a few believed the precipitate in **(c)** to be blue rather than white.

Conclusions

Candidates often had sufficient evidence to identify correctly the compounds in **R** and **S** but did not secure the marks. A significant number chose to provide the names or formulae of the metal ions only. The other common error was to name **S** imprecisely as copper chloride.

CHEMISTRY

Paper 5070/41
Alternative to Practical

Key messages

Candidates are advised that in questions that require them to plan an experiment, they should read the question carefully, taking note of all the information provided that is designed to assist them in answering the question. They should also ensure that all the details requested in a question are included in their answers if they are to obtain full credit.

Candidates should know how to separate mixtures of substances that are soluble from those that are insoluble in a solvent.

Candidates should be familiar with the practical techniques used in making up standard solutions and completing titrations.

General comments

The Alternative to Practical Chemistry paper is designed to test the candidate's knowledge and experience of practical chemistry.

Skills required include knowing the names of common pieces of chemical apparatus and their uses, recall of experimental procedures, handling and interpretation of data, drawing of graphs, analysis of unknown salts, calculations and the planning of experiments. The majority of candidates show evidence of possessing many of these skills, although particular attention needs to be paid to the points highlighted in the key messages above.

Comments on specific questions

Question 1

(a) Both chlorine and oxygen were accepted as the gas given off at the anode, as it would depend on the concentration of the acid. The test for chlorine was well known; a lighted splint rather than a glowing splint was sometimes wrongly used in the test for oxygen.

(b) Many candidates correctly identified the gas as hydrogen; there was some confusion with the test where a lighted splint should be used.

(c) A suitable replacement electrolyte was generally correctly named and the gas produced identified and tested.

Question 2

Some very good answers were seen scoring full marks; many candidates did not read the question carefully and did not take note of what was required in their answer. Several candidates did not realise that mixing soot and heptane was the first stage. Some added water and others suggested fractional distillation of the soot. An explanation of what occurs at each stage of the process was often omitted.

Question 3

(a) A significant number of candidates showed water flowing in the wrong direction in the condenser. Many candidates thought that the condenser was in the wrong position or missing a thermometer rather than the errors with the position of the bung.

(b) The majority of candidates correctly named the condenser. Many realised that it turned a vapour or gas into liquid; only a minority mentioned that the liquid returned to the distillation flask.

Question 4

(a) The mass of the sample was almost always correct.

(b) The use of a volumetric flask to make up solutions was not well known. Candidates should know that these flasks are very important and very accurate pieces of apparatus used in volumetric analysis.

Many candidates thought that the residue was washed with distilled water to remove impurities rather than to transfer any remaining acid to the volumetric flask.

(c) The majority of candidates gave the correct colour change of the indicator; a significant minority gave it in reverse.

(d) Many candidates stated that if three titrations were performed an average could be found; most did not state that this would lead to a more accurate result. The titration results were generally correct. The average volume should be calculated from the closest two titres. Some candidates used all three titres in calculating this volume while others used titres 2 and 3 and assumed that titre 1 should be ignored as it was a trial.

(e)–(l) In the calculations, errors are carried forward so that candidates are given credit for correct chemistry even if an error has been made in an earlier part. Candidates were penalised once if answers were given to less than three significant figures except when the third figure was zero or the second and third figures were both zero. Most candidates scored some calculation marks and many scored all of them.

(m) Most candidates thought that leaving water in the flask would make the titre larger because there was a bigger volume of liquid in the flask. They were unaware that the titre would be unchanged if the amount of acid in the flask was unchanged. Furthermore, they were unaware that conical flasks should be washed out with water between titrations.

Question 5

(a) A coloured solution indicates that a transition metal compound or ion is present. Most candidates omitted the word ion or compound.

(b) The observations were generally correct.

(c) Many candidates gave the observation of a green precipitate that was soluble in excess sodium hydroxide; very few mentioned the green solution that was then formed.

(d) The test for chloride ions was well known.

Question 6

(a) Most candidates gave correct safety precautions; the word googles was far more common than the correctly spelled goggles.

(b) Quite a large number of candidates thought that the cotton wool plug was there to prevent rather than allow the escape of gas. Prevention of the escape of hydrogen peroxide was an acceptable answer.

(c) Many candidates correctly stated that mass and time were the required measurements; volume and temperature were often seen.

(d) Some diagrams were good; the general standard was poor, even when the correct apparatus was used.

The points on the graph were usually plotted accurately and joined as instructed in the question.

(e) Most candidates correctly used their graph to determine the volume of oxygen produced in the first 50 seconds; only a few subtracted this answer from the reading at 100 to find the volume produced in the second 50 seconds.

The average volumes of gas given off each second were often correctly calculated using the candidates' answers but as the second of these was usually wrong the explanation of the difference in terms of rates of reaction became impossibly difficult. The word concentration was rarely seen.

CHEMISTRY

Paper 5070/42
Alternative to Practical

Key messages

Candidates should be familiar with the names of the apparatus and the practical techniques used in quantitative analysis. This includes making up standard solutions using a volumetric flask. Candidates should also be aware of the reasons why the different steps in the procedure are used.

When candidates are asked for observations, this means they must describe:
- colour changes
- physical states i.e. solid, liquid or gas
- the formation of precipitates
- effervescence or bubbling when a gas is evolved.

It is unnecessary to give the names of substances when asked only for observations

Comments on specific questions

Question 1

(a) Candidates are expected to deduce the electrolysis products of concentrated aqueous sodium chloride and aqueous copper(II) sulfate.

Effervescence or bubbling was often omitted in the observations section for the two gases that were given off. Copper was often described as blue in colour. Chlorine was occasionally named as chloride. The appearance of chlorine was least well recalled. Tests for gases were often given even though they were not requested.

(b) This was answered quite well; burning splints were occasionally used instead of glowing splints. A few candidates described a test for hydrogen.

Question 2

(a) The colour change was quite well known. A few candidates gave the colour change of potassium dichromate i.e. orange to green.

(i) A large number of candidates knew the word chromatography and were able to spell it correctly.

(ii) This was answered quite well. Some confusion was evident in cases where candidates referred to the ink needing to be above the base line. Candidates are told that ethanol evaporates easily at room temperature. This should have been enough to suggest to candidates that a lid was required. Many candidates stated both that the ink was below the solvent level and that the baseline was below the solvent level. These are essentially the same point.

(c) There is no need to heat the solvent in a chromatography experiment. However, the flammability of ethanol means that there should be no flames nearby.

Question 3

(a) The majority of candidates knew that carbon dioxide turns limewater milky.

(b) (i) Better responses mentioned the piece of apparatus and the method of ensuring that the apparatus produced a constant amount of heat in all four tests. If a Bunsen burner was used, there are several ways of ensuring that the amount of heat it produces is constant. These include opening the air hole by the same amount in each test. Many other methods could have been chosen. Using a thermometer only goes part of the way to ensuring that the amount of heat supplied is constant.

(ii) 'A fair test' means that only one thing is varied in an experiment (in this case different carbonates are used) and everything else that is likely to affect the result should be kept constant. In this case the volume and concentration of the limewater should have been the same in all four tests. Factors involving the carbonates, including mass, number of moles and particle size could also have been chosen. The question asks for two 'other' ways, it was therefore inappropriate to mention regulating the heat source in answer to this question.

(c) The majority of candidates recognised that because copper(II) carbonate caused the limewater to turn milky in the shortest time, it decomposed the fastest. Some candidates listed all four carbonates, without specifying which was fastest.

(d) Several alternative methods were seen in answer to this question. One of the most common was to repeat the experiment and take the average result. It is preferable to describe the use of concordant results. This means that any measurements that were obviously a long way from the majority could be discarded and not included in the average. The same technique is used in choosing the most suitable volumes in a titration to use in the calculation i.e. results that are concordant are used rather than taking an average of all the results. Some candidates gave answers that were more suitable to answer **(b)(i)** or **(b)(ii)**.

Question 4

(a) This was almost always correct.

(b) (i) This was usually correct. Burette was the most common incorrect answer.

(ii) The appropriate items are known as pipette bulbs and pipette fillers. The word filter was seen occasionally instead of filler.

(iii) Many candidates realised that the safety apparatus was used in order to avoid drinking the solution that is pipetted.

(c) (i) A volumetric flask is used to make up solutions in quantitative analysis. It is essential that candidates know its name and are familiar with its use. Conical flask and flat bottomed flask were common answers.

(ii) In order to transfer all the acid from the beaker to the volumetric flask, the beaker needs to be washed out more than once. All of the washings must be transferred to the volumetric flask. This ensures that all the acid in the beaker is transferred to the volumetric flask to form the titration solution, rather than some being discarded. It was clear that this technique was unfamiliar to the majority of candidates. Many confused washing with cleaning or sterilising; others referred to impurities.

(d) (i) A comparison was required here i.e. a pipette is more accurate than a measuring cylinder. Mentioning that a pipette is accurate only goes half way to answering the question.

(ii) The colour change was quite often correct. Candidates needed to realise that there was acid in the conical flask, therefore the indicator changed from its acidic colour to its neutral colour at the end-point.

(e) The vast majority of candidates were able to complete the table and calculate the average volume successfully. There was very occasional evidence that candidates had read the burettes ‘upside down’ e.g. in titration 1, giving the final reading as 24.8 rather than 23.2.

(f) - (i)
Large numbers of candidates were able to perform all steps of the calculation correctly. It is expected that all numerical answers are given to three significant figures (including trailing zeros). There were occasional examples of incorrect rounding and quoting answers to less than three significant figures, but these were not common.

(j) If a negative answer is achieved this should have indicated to the candidate that they had made an error in previous steps. This should have been a prompt to go back and check earlier steps. Instead, candidates were inclined to subtract **(i)** from **(h)** rather than **(h)** from **(i)**.

(l) The M_r was occasionally seen as 57.

(m) If a candidate achieved an answer greater than 100% it should have indicated that they had made an error in previous steps. This should have been a prompt to go back and check earlier steps. Instead, candidates were inclined to calculate **(a)** ÷ **(l)** · 100 rather than **(l)** ÷ **(a)** · 100.

(n) Only 2 or 3 drops of indicators, such as methyl orange, are used in titrations between acids and alkalis. The reason is that methyl orange is a weak acid and the more acid that there is in the conical flask, the more alkali that will needed to neutralise it. Thus if 3 cm^3 of methyl orange is used in the titration, more sodium hydroxide will be required to react with it.

The fact that methyl orange is a weak acid does not affect the amount of sodium hydroxide that reacts with it.

Question 5

(a) **L** was regularly described as a transition metal or transition element rather than as a compound containing a transition element or containing ions of a transition element. This was despite the fact that **L** is described as a compound in the introduction to the question.

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

(c) This was answered quite well by the majority of candidates. Those who were aware that the precipitate dissolved in excess of aqueous sodium hydroxide very rarely attempted to give the colour of the solution that was formed.

(d) This was answered fairly well by the majority of candidates. The use of silver nitrate was the most common error.

Question 6

(a) (i) Very few candidates realised that it was necessary to measure the mass of the burner *before and after* the ethanol was burnt and it was also necessary to measure the temperature of the water *before and after* the ethanol was burnt. Those who read the question carefully, realised that if the student is provided with a burner already containing ethanol it is impossible to measure the mass of ethanol on its own. Similarly candidates should realise that thermometers measure temperatures as opposed to temperature differences.

(ii) The candidates are told that the student assumes that all the heat energy is transferred to the water. However, heat would be lost to the surroundings. Some heat would also have been transferred to the metal can. These reasons (and others) account for the temperature not increasing as much as predicted. There is no evidence to suggest that the water would evaporate.

(iii) A glass beaker was a common suggestion. This would not lose heat as much, but since glass is a poor thermal conductor, a lot of heat from the flame would not reach the water. This is why metal cans are always used in such experiments. Using a lid and insulating the can were sensible suggestions as to how heat loss can be minimised.

(b) Most candidates performed well on the graph.

(c) Most candidates identified the anomalous point and suggested what the correct result should be.

(d) Many candidates used the graph to deduce the required temperature rise. Some did not extend the graph as requested.