

CHEMISTRY

Paper 5070/11
Multiple Choice

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

General comments

Questions 6 and 37 were found to be easy.

Question 10 was found to be particularly challenging. There was evidence of candidates guessing the answer to Question 19.

Comments on specific questions

The choice of distractor in the following items shows where candidates may have gaps in their knowledge, skills and/or understanding.

Question 2

The majority of candidates gave the correct answer; a common incorrect choice was option B. This suggests that although candidates understood the link between rate of diffusion and temperature, they were less familiar with the link between rate of diffusion and molecular mass.

Question 4

Candidates struggled with this question. Candidates may have found the need to include inner-shell electrons in their calculations and to account for a bond that is not displayed more challenging.

Question 10

Candidates had to work out the number of moles of water, multiply by the Avogadro number and then multiply by 3 to convert the number of molecules to a number of atoms. Only a minority of candidates selected the key. Option **A**, which represents the number of molecules rather than the number of atoms, was a popular choice. This suggests many candidates were unfamiliar with this type of multi-stage calculation.

Question 11

This was a relatively difficult calculation, with some evidence of guessing between options **A**, **B** and **C**, but a significant number of candidates did correctly select option **C**.

Question 16

Some candidates chose option **C**. This suggests a misunderstanding when trying to distinguish the effect of temperature on the rate of a reaction and its effect on the position of the equilibrium. Other candidates incorrectly selected option **B**. Candidates often make mistakes with the logic required to work out the effect of temperature on the position of an equilibrium.

Question 19

There is some evidence of guessing here, particularly amongst candidates who performed less well overall. The question depends on candidates knowing the solubilities of the compounds outlined in the syllabus. They also needed to appreciate that four possible compounds could be formed by mixing the two solutions.

Question 21

Many candidates chose option **D**, suggesting that although the trend in reactivity going down Group I was well understood, the trend in melting points was less familiar to candidates.

Question 26

Slightly more candidates incorrectly chose option **B**, rather than correctly choosing option **D**. This suggests that quite a high number of candidates were unfamiliar with the principle of sacrificial protection.

Question 30

Relatively high numbers of candidates of all abilities incorrectly chose options **A** or **B**. This suggests that many candidates were unfamiliar with more complex isomer questions where both positional and structural isomerism are possible in the same molecule.

Question 39

Many candidates of all abilities incorrectly chose option **C**. Candidates needed to understand that the acidic gas would react with the base if the base was used as a drying agent.

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Paper 5070/12
Multiple Choice

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

General comments

Candidates found **Question 6** and **Question 28** to be easy.

Question 38 was the hardest question on the paper. Candidates also found **Questions 9, 13, 22, 31** and **34** to be challenging.

Comments on specific questions

The choice of distractor in the following items shows where candidates may have gaps in their knowledge, skills and/or understanding.

Question 4

Options **B** and **C** were selected by many candidates. These are tempting because in each case the two elements are in the same period. However, this represents a misunderstanding of what happens to atoms when ions are formed.

Question 8

A high number of candidates selected the molecule with the lowest molecular mass (option **C**) rather than the carboxylic acid with the lowest molecular mass.

Question 9

Although the majority of candidates were able to work out that oxygen is in excess, only a minority correctly chose option **C** as the final answer. The calculation depends on recognising that there will initially be equal volumes of the two gases.

Question 13

This was found to be a challenging calculation question. It is possible that candidates chose to guess rather than methodically work through all the steps.

Question 17

Some candidates chose option **B**. Candidates often make mistakes with the logic required to work out the effect of temperature on the position of an equilibrium. Details of the Haber process are on the syllabus, so candidates should be familiar with the effect of temperature.

Question 22

Candidates had to work through a series of logical steps to reach the correct conclusion. The results indicate that some candidates may have guessed the answer.

Question 23

Incorrect option **B** was the most popular response overall. Candidates overlooked helium when considering whether all noble gases have eight electrons in their outer shell.

Question 31

Candidates found interpreting the information challenging and the key, option **B**, was only the third most popular response overall.

Question 34

Many candidates chose option **B**. These candidates overlooked the fact that although propene has three carbon atoms, methene does not exist.

Question 38

Option **C** was by far the most popular response. The question is asking about chromatography in a slightly unusual way. Candidates who selected distillation have overlooked the fact that both solids would still be mixed together at the end of the process.

CHEMISTRY

Paper 5070/21 Theory

Key messages

- Candidates need to read questions carefully so that they answer what is being asked, e.g. **Question 3(a)(ii)**, where the diagram needed to be used to explain the endothermic change and **Question 3(c)**, where the question asked for the answer to two significant figures.
- It is advised that candidates show all of their working in calculations so that if the final answer is incorrect, error carried forward marks could be awarded.
- Undertaking practical work enables candidates to know observations from experiments, e.g. **Questions 4(c)(ii), 6(d), 9(c) and 9(e)**.
- Candidates need to be able to construct and balance ionic equations.

General comments

Candidates were generally well prepared for this examination and appeared to have had sufficient time to complete the paper as only some of the more demanding questions were omitted.

Many gave detailed explanations for questions, whilst others stated answers rather than explaining them.

Use of chemical terminology was often confused.

Comments on specific questions

Question 1

- (a) (i) Almost all candidates chose methanol. All other responses were seen occasionally.
- (ii) Many candidates chose ethanol. All the other responses were seen with **A** and **E** being the most common.
- (iii) Most candidates recognised the carboxylic acid. **E** and **G** were popular incorrect responses.
- (iv) Some candidates confused saturated and unsaturated and chose compound **D**. Others did not know the meaning of the term hydrocarbon. **E** was a popular incorrect response.
- (v) Some candidates chose the correct ester. **F** and **G** were the more popular incorrect responses.
- (b) Molecular formula was quite well known and many gave the correct two compounds. **E** or **F** and **G** were the most popular incorrect responses.

Question 2

- (a) A difference between the isotopes was well known. Non-creditworthy responses included different atomic mass and different neutrons, without specifying number. Different relative atomic mass was a common incorrect response.

- (b) Candidates found this a little challenging. Many thought it was because they were the same element or had the same number of protons. Some gave the definition for isotopes in terms of protons and neutrons.
- (c) Candidates found this challenging and a significant number omitted the question. Adding the mass numbers of the isotopes and dividing by 4 was a common response.

Question 3

- (a) (i) The majority of candidates identified the energy changes correctly. Energy taken in, endothermic and positive were common responses for **A**, energy given out, exothermic and positive were common responses for **B** and a small number reversed the changes.
- (ii) Candidates found this challenging, with few explaining how the energy pathway diagram showed that the process was endothermic. Many discussed the energies needed to break and make bonds or just the absorption of energy.
- (b) The test for carbon dioxide was quite well known. Some gave the tests for hydrogen or oxygen.
- (c) Better performing candidates showed the steps in their working to arrive at the correct answer. Common errors included incorrectly calculating the number of moles of carbon dioxide as 0.23×24 , $0.23 \div 44$ or $230 \div 24$. Some omitted the stoichiometry from the equation and so did not multiply the number of moles of carbon dioxide by 2. Many could not calculate the M_r of sodium hydrogencarbonate, with 108 being a common number. A significant number did not give their answers to the two significant figures requested in the question.

Question 4

- (a) (i) The arrangement and motion of particles in a liquid were not well known. Many had spaces between the molecules, had the molecules in a fixed position or arranged regularly.
- (ii) Candidates found this very challenging. Common incorrect responses included weak covalent bonds, intermolecular forces between atoms, ionic structure with intermolecular forces and weak forces of attraction without specifying what they were between.
- (b) (i) Better performing candidates gave at least one correct property. Many thought the melting point and boiling point were low, gave electrical conduction as either high or low without specifying states or gave chemical properties.
- (ii) The ionic half equation proved very challenging. Many gave the reverse equation, added an electron to the atom to get the cation or had the ion losing electrons.
- (iii) This ionic equation proved even more challenging than the one in **4(b)(ii)**. Few appreciated that fluorine is diatomic, many added an electron to the fluoride ion both on the left of the equation or on the right of the equation and many gave the symbol as $F\cdot$.
- (c) (i) The products were quite well deduced. Common errors included: potassium iodide and chlorine, water and carbon dioxide, oxygen and hydrogen, chlorine iodide and potassium chloride.
- (ii) The observation was not well known. Common incorrect responses included lilac to colourless, brown to colourless, purple and red-brown.

Question 5

- (a) Better performing candidates named at least one physical property. Many gave chemical properties including catalyst, variable oxidation state and coloured compounds.
- (b) (i) Whilst many candidates appreciated that nickel has delocalised electrons, which was not creditworthy, far fewer described these electrons as mobile.
- (ii) The reason for ductility was not known by most candidates. Many described either molecules moving or strong or weak intermolecular forces.

- (c) The empirical formula calculation was quite well known. Common errors included omitting nickel, using nitrogen for nickel both in terms of the calculation or as the symbol for nickel and having hydrogen instead of oxygen.
- (d)(i) The ionic equation for the reaction proved very challenging. Common incorrect responses included Ni_2 , Ni^+ and the addition of HCl .
- (ii) The prediction proved very challenging. Most candidates thought there would be no reaction and of those that did appreciate there would be a reaction, many either could not explain their suggestion or thought nickel was more reactive than copper ions or that an alloy was formed.

Question 6

- (a) Better performing candidates drew a correct diagram. The most common error was to put four bonding electrons between the two carbon atoms. Many also changed the formula, with the most common being ethene, C_3H_2 and C_3H_5 .
- (b)(i) Many candidates calculated the number of molecules correctly. Some stopped when they had calculated the number of moles of ethyne. Common incorrect responses included either dividing or multiplying 0.13 by the Avogadro constant.
- (ii) This proved very challenging and a significant number of candidates omitted the question. Many repeated their answer **to (6)(b)(i)** or gave the number of atoms in one molecule i.e., 4 or gave 2.
- (c) The term hydrocarbon was well known. Some did not appreciate the exclusivity to carbon and hydrogen or discussed the molecule containing carbon and hydrogen bonds.
- (d) Better performing candidates knew the colour change. Incorrect responses included red-brown for bromine, reversing the colour change and using clear instead of colourless.
- (e) The formula was quite well deduced. Common errors included Ca_2C , CaC , Ca_2C_4 and Ca_2C_2 .

Question 7

- (a)(i) Cracking was quite well known. Common incorrect responses included condensation, polymerisation and addition.
- (ii) The conditions were quite well known. Nickel and phosphoric acid were seen frequently as the catalyst.
- (b)(i) Candidates found this challenging, with many discussing the effect of temperature on the position of equilibrium instead of on the rate of reaction. Non-creditworthy responses included no mention of particles, particles gaining energy with no mention of kinetic energy or moving faster and omitting the collisions being more successful.
- (ii) Candidates found this a little challenging. Many had the position of equilibrium moving to the left or not moving at all. Of those that knew the movement was to the right, many omitted gas in their explanation. The reaction moving right is not creditworthy; it is the position of equilibrium which moves to the right.
- (c)(i) The structure was quite well known. Common incorrect responses included a double bond between the carbons, one repeat unit and no continuation bonds.
- (ii) The environmental challenges were quite well known. Vague terms such as water pollution, air pollution and land pollution are not creditworthy. Some candidates discussed toxic gases being produced but omitted to include that it is combustion of plastics that cause these toxic gases to form. Harmful is also non-creditworthy.
- (d)(i) This proved very challenging with many candidates using addition as part of their explanation. Common non-creditworthy responses included adds across the double bond, double bond breaks and hydrogen is added.

- (ii) The displayed formula of the product was quite well known. Ethanol was the most common response. Other structures included ethene, three-valent carbon atoms and molecules including nickel.

Question 8

- (a) The formula was well deduced. The most common error was $C_{14}H_{28}$.
- (b) The trend in viscosity was quite well known. The most common incorrect response was methane and decane was also quite common.
- (c) (i) Use of a fractionating column was well known, as was separation by boiling point. Few heated or vaporised the petroleum and some separated on the basis of melting point, density or volatility.
- (ii) Use of refinery gas was quite well known. Incorrect responses included jet fuel, lubricant, power plant fuel or just the vague term 'fuel'.
- (iii) The use of naphtha was slightly less well known, with fuel, rocket fuel, jet fuel and making roads seen commonly.

Question 9

- (a) Anhydrous was well known. Incorrect responses included contains water or contains no hydrogen.
- (b) The colour was very well known. Common responses included pink and green.
- (c) The qualitative test for copper ions was not well known and a significant number omitted the question. The most common responses were white precipitate, green precipitate and it is insoluble.
- (d) This test also proved challenging. Common incorrect responses included colourless, blue solution, green precipitate and gas given off. A significant number omitted the question.
- (e) This proved very challenging. Many candidates gave a product at the electrode, gave a selection of ions which could be attracted to the electrode or gave equations, none of which included observations.
- (f) Only the better performing candidates gave a valid explanation. Many discussed the movement of electrons and those who appreciated the ions were responsible either said they were free or that they carried a charge, with few citing them moving.

Question 10

- (a) The percentage of oxygen in the air was well known. 16% was the most common incorrect response.
- (b) (i) Global warming and climate change were well known. Ozone depletion and acid rain were the more common incorrect responses.
- (ii) Reforestation and afforestation were well known. Non-creditworthy responses included stopping industrial emissions, catalytic converters, low carbon fuels and electric vehicles.
- (c) (i) Oxides of nitrogen were well known. Incorrect responses included carbon monoxide, carbon dioxide, nitrogen and nitrates.
- (ii) Methods of reducing sulfur dioxide emissions were quite well known. Catalytic converters and reducing the number of power stations were seen commonly.

CHEMISTRY

Paper 5070/22 Theory

Key messages

- Candidates should be able to apply chemical concepts to unfamiliar contexts.
- Candidates found questions involving the Avogadro constant and calculations with numerical values expressed in standard form very challenging.

General comments

Candidates appeared to have sufficient time to complete all of the examination paper. Candidates were often able to interpret and explain data given in questions.

In some quantitative questions, candidates did not show sufficient working and as a result, error carried forward marks could not be awarded.

Candidates found writing ionic half equations very challenging. Candidates must appreciate that equations at the anode will show electron loss and electrons at the cathode will show electron gain.

Candidates must not repeat information given in the question but must be able to interpret and use this information.

Comments on specific questions

Question 1

This question was about organic chemistry. Most candidates gave the letter of the compound.

- (a) (i) Some candidates were able to recognise the structural formula for methanoic acid. The most common incorrect answer was methanol.
- (ii) Some candidates recognised that ethene is hydrated to form ethanol.
- (iii) Candidates found this question quite demanding and rarely recognised $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$.
- (iv) Candidates often recognised the alkene $\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2$ is used to make an addition polymer.
- (v) Candidates often recognised that $\text{CH}_3\text{COOCH}_3$ was an ester.
- (b) Candidates often chose compounds **E** and **G** as structural isomers.

Question 2

This question was about the isotopes of titanium.

- (a) Many candidates were able to describe a difference between the two isotopes. The most common answers were that there was a different number of neutrons, or the mass or nucleon number was different. Other candidates gave more detailed answers, stating that one isotope had an extra neutron or quoted the actual number of neutrons in each isotope. The most common misconception was to state that the isotopes had different percentage abundances. Some candidates gave an imprecise answer, such as the isotopes had different neutrons without mentioning the number of neutrons.
- (b) Candidates often appreciated that the number of electrons was the same. Other candidates stated that the proton number was the same, but this was not enough unless the answer also referred to the number of electrons. Another common incorrect answer was that they were both the same element, without referring to number of electrons. Some candidates referred to both isotopes being in the same group which was not given credit.
- (c) A significant proportion of the candidates did not attempt the question. Some candidates were able to show the calculation of a weighted average. Other candidates did not show the correct division by 100. A common misconception was just to calculate a simple mean value.

Question 3

This question used the context of the reaction between aluminium and dilute hydrochloric acid to assess reaction pathway diagrams and stoichiometric calculations.

- (a) (i) Candidates often recognised the activation energy and the enthalpy change. Some candidates described the changes as endothermic and exothermic, but this was not given credit unless the correct names or symbol for the energy change was given.
- (ii) Candidates often gave an answer that referred to energy being absorbed and energy being released but did not refer to the reaction pathway diagram. The best answers either stated that the energy of the products was less than the energy of the reactants or described that arrow **B** pointed downwards.
- (b) Many candidates were able to describe the chemical test for hydrogen. The most common misconception was to describe a test for oxygen using a glowing splint.
- (c) Candidates found the calculation very challenging and often did not give the final answer, 0.27 g, to the correct number of significant figures. The best answers used the molar volume to calculate the moles of hydrogen made, then used the correct mole ratio to work out the moles of aluminium and finally worked out the mass of this amount of aluminium. Candidates often did not use the molar volume and used 0.336 as the number of moles of hydrogen. Candidates also found the mole ratio challenging and so often used just a 1 : 1 ratio. At the end of the calculation, some candidates used 54 g as the molar mass of aluminium rather than 27 g.

Question 4

This question was about elements in Group VII.

- (a) (i) Candidates were often able to describe the arrangement and motion of molecules in fluorine gas. The most typical answers referred to random arrangement, molecules moving fast or molecules far apart.
- (ii) Candidates often referred to weak intermolecular forces or alternatively, weak attraction between molecules. Common misconceptions included reference to the presence of weak covalent bonds or having weak intermolecular attractions between atoms or bonds rather than molecules. A small proportion of the candidates explained that it was because the boiling point was less than room temperature, but this was not credited.

- (b)(i) Candidates typically referred to high melting or boiling points and described that molten or aqueous lithium bromide conducts electricity. A small proportion of the candidates gave physical properties typical for metallic elements. Candidates that referred to solubility had to refer to the actual solvent.
- (ii) Candidates often found this ionic half-equation challenging. Typically, they gave equations involving the addition of an electron to lithium ions.
- (iii) Candidates found this ionic half-equation more demanding than the one in (b)(ii). The most common answers used bromine atoms rather than bromine molecules in the equation and typically included electrons on the incorrect side of the equation. Some candidates used e^+ rather than e^- for an electron.
- (c) Some candidates gave the correct products, but other candidates gave chlorine bromide or bromine chloride as a product.

Question 5

This question was about nickel and nickel compounds.

- (a) Hydrogenation or an example of hydrogenation was the most common answer. Two common incorrect answers were as a catalyst in the Contact process and the Haber process. A common misconception was that nickel catalyses hydration.
- (b) The most common answers given were coloured compounds and more than one oxidation state. A common misconception was to describe nickel as coloured rather than nickel compounds being coloured. Some candidates gave physical properties rather than chemical properties.
- (c)(i) Candidates found this question very challenging and rarely appreciated that layers of atoms could slide over one another. Many candidates did not appreciate the importance of the layered structure within a metal.
- (ii) Candidates often appreciated that particle sizes were different in the alloy but rarely linked this to the inability of atoms or layers to be able to slide over one another. The best answers used the blank space to draw labelled diagrams to illustrate the answers.
- (iii) Many candidates appreciated that stainless steel would not corrode or rust as fast as iron. Some candidates referred to the alloy being a good thermal conductor or having a high melting point, but these answers were not accepted.
- (d) Many candidates were able to calculate the empirical formula as NiH_2O_2 . A significant proportion of the candidates used N as the symbol for nickel rather than Ni. Some candidates did not calculate the percentage of nickel and other candidates used the molar mass of O_2 and H_2 rather than the molar mass of O and H. Only a small proportion of the candidates used the proton number rather than the relative atomic mass to work out the amount in moles.
- (e) Candidates were often able to make a correct prediction about the position of equilibrium but had more difficulty explaining their prediction. Candidates had to refer to the position of equilibrium shifting or moving to the right rather than the right-hand side was favoured. In terms of the explanation, many answers neglected to include the reference to moles of gases or volume of gases in their answers.

Question 6

This question was about hydrogen peroxide.

- (a) Most candidates attempted to draw a covalent dot-and-cross diagram but rarely drew a correct diagram. Candidates were most likely to draw the oxygen-oxygen single bond but sometimes drew a double bond instead. Candidates rarely got the correct number of lone pair electrons around the oxygen atoms

- (b)(i) Candidates found this question very challenging possibly because the numerical values were so large and written in standard form. Many candidates did not know where to start and as a result did not calculate the amount in moles of hydrogen peroxide. A common error was to multiply the mass of hydrogen peroxide by the Avogadro constant.
- (ii) A significant proportion of the candidates did not attempt the question. Some candidates appreciated that hydrogen peroxide molecule contained four atoms but could not take the calculation any further.
- (c) Candidates often gave answers that referred to oxidation and reduction or to reducing agents and oxidising agents. The best answers clearly stated that hydrogen peroxide was both a reducing agent and an oxidising agent. Some answers were confused and described the reagents rather than the hydrogen peroxide, for example potassium iodide was a reducing agent. A common misconception was to describe hydrogen peroxide as an amphoteric oxide.
- (d) Some candidates deduced the correct formula of BaO_2 , although common misconceptions were Ba_2O_2 , BaO and Ba_2O .
- (e)(i) The candidates often gave good answers, but some candidates just referred to particles having more energy without referring to kinetic energy or the particles moving faster. Other candidates did not link kinetic energy with a particle and just stated that the kinetic energy increases. The idea of more successful collisions was often mentioned within the answers given.
- (ii) Candidates often appreciated that the activation energy was lowered by the presence of a catalyst.

Question 7

This question was about the condensation polymer PET.

- (a) Candidates struggled to recall the names of the two types of monomer, and often gave the name of the type of functional group, carboxylic acid and alcohol rather than dioic acid and diol.
- (b) A significant proportion of the candidates did not attempt the question. Some candidates recognised that the small molecule made was water.
- (ii) A significant proportion of the candidates did not attempt the question. Some candidates were able to draw the correct structure that included the ester linkages and the continuation bonds. Other candidates did not draw the correct ester linkage, often missing bonds in the ester linkage or adding extra oxygen atoms. A small proportion of the candidates did not include the continuation bonds. Some candidates drew $1\frac{1}{2}$ repeat units rather than two whole units.
- (iii) Candidates often gave more than two environmental challenges. The most common answers were that PET is non-biodegradable, fills up landfills and when burnt, gives off toxic gases. Some candidates gave answers that lacked detail and stated water pollution, land pollution or atmospheric pollution without offering any more explanation. Some candidates just stated that PET gives greenhouse gases and toxic gases without referring to these gases being products of incineration.
- (c) The most common correct answers were nylon and proteins.

Question 8

This question was about an unsaturated carboxylic acid.

- (a) Although most candidates appreciated that an unsaturated compound has a double bond, some candidates did not specify that the double bond must be between two carbon atoms.
- (b) Candidates often appreciated that when the compound **X** reacts with aqueous bromine, there is a colour change to form a colourless solution. However, a common misconception was that the initial colour of aqueous bromine was red rather than orange.

- (c) Many candidates were able to recall that the term 'weak' referred to partial ionisation or incomplete dissociation.
- (d) Candidates often appreciated that carbon dioxide was formed in the reaction.
- (e) Candidates found this question quite challenging and often did not appreciate the need for an alcohol to react with **X**, or the need for an acid catalyst. A significant proportion of the candidates did not attempt the question.
- (f) (i) Candidates found this question challenging and often gave incorrect answers. Oxygen or acidified potassium manganate(VII) were the most common answers. Fermentation was a common incorrect answer.

(ii) Many candidates appreciated that sodium ethanoate was made in the reaction, but the candidates were less certain of the second product. Some candidates gave water, but others gave a gas such as hydrogen.

Question 9

This question was about zinc chloride.

- (a) Candidates found this question very challenging and they could not recall an appropriate definition. The most common answer was that hydrated means it contains water. Only a small proportion of candidates referred to water of crystallisation or that a compound was bonded or combined with water.
- (b) Many candidates appreciated that a white precipitate was formed but were less clear about the effect of adding excess ammonia. Some candidates also described the formation of gas bubbles rather than the precipitate redissolving into a colourless solution.
- (c) Many candidates appreciated the formation of a precipitate but not all of these candidates gave the correct colour.
- (d) Candidates found this question challenging and rarely managed more than two correct products. The candidates often gave oxygen and chlorine at the anode but not necessarily linked to the correct solution. Some candidates had zinc as the product at the cathode rather than hydrogen. A small proportion had the anode products as cathode products and vice versa. Some candidates gave the formulae of ions present rather than the actual product.
- (e) Many candidates referred to electrons in their answers rather than the presence or lack of mobile ions.

Question 10

This question was about water.

- (a) (i) Candidates often gave substances without an adequate explanation. The best answers were microbes or bacteria that cause disease or fertilisers that deoxygenate water through eutrophication. Some candidates referred to plastic but did not give a detailed reason why plastics were harmful.

(ii) A significant proportion of the candidates did not attempt the question. The most common beneficial substance was oxygen. Many candidates gave an explanation that was linked to respiration of aquatic organisms. Some candidates gave answers that did not refer to river water for example chlorine to kill microbes.

- (b) Many candidates could not recall both the name of the processes and the reason for the process. Chlorination was the most common answer and candidates often referred to killing microbes. Although candidates often stated filtration or sedimentation, they were not always able to explain why in terms of the removal of solids. It was not sufficient just to remove substances, there had to be a specific mention of solids or a named solid, such as wood or mud. Candidates who recalled carbonation often appreciated the reason for its use. Fluoridation was sometimes given but no detailed reason for its addition was given by the candidates.
- (c) A significant proportion of the candidates did not attempt the question. Many candidates were not able to describe in detail the qualitative test for water. Often candidates gave part of the test but ignored one vital point, for example using copper(II) sulfate without stating it was anhydrous. Some candidates gave the test for hydrogen, while others gave the result of a test with a named acid-base indicator.
- (d) Candidates often knew that pure water had a boiling point of 100 °C but did not always appreciate the effect of soluble impurities on the boiling point.

CHEMISTRY

Paper 5070/31 Practical Test

Key messages

Question 1 – Candidates need to carefully read the question stem to clearly understand the task. Marks were missed in this question by not following the instructions given. Candidates should reflect on values they attain. If the values do not give the pattern indicated in the question, then they should double-check their work.

Question 2 – Candidates need to make full use of the 'Notes for use in qualitative analysis' sheets at the rear of the question booklet and to carefully read the question stem.

Question 3 – A number of candidates seemed unfamiliar with the use of alcohol burners. Candidates should be able to apply their practical skills even with unfamiliar contexts.

General comments

Candidates need to keep in mind that the wording of the question stems is there to help them. They should read the information given in the question paper carefully before attempting the questions. This was particularly relevant in **Questions 1(a), 1(b), 2(e)** and **4**.

For **Questions 2(b), 2(e)** and **2(h)**, candidates should have used the 'Notes for use in qualitative analysis' pages. They are advised that even if they think they know the observation and result, they should double-check by referring to these notes.

Question 3 relied on the careful reading of the question, but also on a well-organised answer. Candidates should use the bullet-pointed statements as a guide to what they need to include in their answer.

Comments on specific questions

Question 1

Candidates were instructed to measure a set of temperature changes of a neutralisation reaction.

- (a) Most candidates successfully recorded the nine temperatures. They were required to record measurements and subtractions to $.0^{\circ}\text{C}$ or $.5^{\circ}\text{C}$, which most candidates did. Some candidates missed the ' $.0^{\circ}\text{C}$ ' for whole number values. Their values needed to show temperature rises in the first three values, then subsequent decreases. The majority of candidates carried out their practical successfully and got this pattern of results. Correctly calculating all the temperature changes was achieved by most candidates. However, a significant minority calculated the values incorrectly, often by subtracting the previous temperature, rather than the initial temperature. The method candidates should follow was described in the question stem. Better performing candidates take their time and carefully read the instructions. Finally, candidates needed to obtain a maximum temperature change value close to the Supervisor's value (within 1.0°C).

- (b) Candidates needed to correctly plot a graph of their values of temperature changes from (a). The y-axis needed to be labelled 'temperature change / °C'. While most candidates gave the correct label, some candidates omitted the units. A linear scale on the y-axis was also needed. This scale had to be sufficient for all of their values to be plotted and for the points to occupy at least half of the graph paper grid. Accurate plotting of the candidate's temperature change values to $\pm$ half a small square of the correct position was then needed. Candidates were then required to draw two lines of best fit. While the lines were dependent on the candidate's values, instructions were given in the question stem. Finally, an intersection point between the two lines of best fit was needed. The main problem seemed to be in plotting temperature changes that were incorrectly calculated in **Question 1(a)**. Error carried forward marks were available, but when the incorrect candidates' values were negative and positive, it made writing the scale, and drawing the lines of best fit, more difficult. Candidates should be encouraged to consider their values, and if the graph is not plotting as they would expect, they should reconsider their calculations to see if errors have been made earlier.
- (c) The majority of candidates correctly determined the volume of Y where their two lines crossed, by reading the value from the x-axis.
- (d) Candidates were given the concentration of sodium hydroxide, 1.60 mol/dm^3 , and its volume, 25.0 cm^3 . They were asked to calculate the number of moles. Most candidates correctly converted the volume to dm^3 , then multiplied the two values together, to give 0.04 moles.
- (e) Candidates were required to calculate the concentration of hydrogen ions in Y. They were instructed to use their answers to (c) and (d) in their calculation. Better performing candidates correctly divided their value for (d) by their reading of the intersection point, (c), (converted to dm^3).
- (f) The majority of candidates successfully recognised that a burette is used, as it is more accurate than a measuring cylinder.
- (g) Candidates were asked why the temperatures are recorded after 30 seconds, rather than immediately. The best responses realised that this is to allow the temperature to reach its maximum. Candidates could also have suggested this would allow a complete reaction to occur. Many candidates stated that it is for the reaction to occur but did not specify that the 'complete' or 'full' reaction needs to occur.

Question 2

This involved carrying out a number of qualitative tests as instructed. In **Questions 2(a) to 2(e)**, candidates tested solution Q and in **Questions 2(f) to 2(h)** candidates tested solution R. In **Question 2**, candidates should have remembered to make full use of the 'Notes for use in qualitative analysis' sheets at the rear of the question paper.

- (a) The candidates were instructed to add universal indicator to solution Q. As Q is an acidic solution, most candidates correctly recorded a red colour.
- (b) Candidates were instructed to add a piece of magnesium ribbon to solution Q. Candidates should have realised that in the question stem for **Question 2**, it is stated that for any tests they should record observations, test any gas evolved and name this gas. The observations that successful candidates noted were effervescence, magnesium disappears, test-tube gets warm. They then tested the gas with a lighted splint, obtained a 'pop' sound and recognised that the gas was hydrogen. A common error was not giving sufficient observations.
- (c) To half of the solution produced after (b), candidates were instructed to add aqueous sodium hydroxide drop-by-drop and then in excess. Most candidates successfully noted the presence of a white precipitate, which was insoluble in excess.
- (d) To the other half of the solution from (b), candidates were instructed to add nitric acid and silver nitrate solution. The majority of candidates noted that a white precipitate was produced.

- (e) Candidates were asked to name the cation and anion in solution **Q**. The anion was successfully named by most of the candidates as chloride, Cl^- ion. Some candidates stated it was indicative of a chlorine anion, rather than a chloride anion. The best responses correctly named the cation in solution **Q** as H^+ , hydrogen. Other responses stated that the cation was calcium, Ca^{2+} . Candidates may have been under this impression because of the results of the sodium hydroxide test in (c). However, (e) clearly states that there is only one cation and one anion in **Q**. Candidates should recognise that by adding the magnesium ribbon, in (b), they have caused another cation to be introduced, Mg^{2+} , which was responsible for the results in (c). Candidates should also have recognised from the results of (a) that **Q** is acidic and would have H^+ cations.
- (f) (i) This question instructed candidates to carry out a flame test on solution **R** and to record the flame colour. Most candidates successfully recorded a blue-green flame.
- (ii) Candidates were asked to state why the air-hole of the Bunsen burner needs to be open. Most candidates correctly stated that this is so that the flame colour can be clearly seen.
- (g) Candidates were instructed to add aqueous ammonia drop-by-drop, then in excess, to solution **R**. The majority of candidates were successful and stated that a light blue precipitate formed, which was soluble in excess, giving a dark blue solution. Some candidates gave the correct colours but were not clear whether it was a precipitate or a solution that they were describing.
- (h) Candidates were asked to identify the cation in **R**. Most candidates correctly answered copper, Cu^{2+} .

Question 3

The question stem shows the candidates a diagram of an alcohol burner. Candidates are told that alcohols are used as fuels to heat water. They are asked to plan an experiment using an alcohol burner to investigate whether methanol or ethanol releases more thermal energy per gram of alcohol burned. The bullet points in the 'Your plan should include' section, indicate statements candidates needed to address.

Better performing candidates gave a plan which included the use of a measuring cylinder, thermometer, balance and a suitable container to heat water in, e.g. a beaker. They stated that the mass of the alcohol burner would be measured before and after heating the water, that the same volume of water would be used for both alcohols, and that the temperature of water would be measured before and after burning the alcohol. To determine which alcohol releases more thermal energy per gram, these candidates stated that the temperature change should be divided by the mass change to give the temperature change per gram. Finally, they indicated that the alcohol with the higher temperature change per gram would be the alcohol that releases more thermal energy per gram burned. Approximately half the candidates successfully described this method.

It was common for candidates to correctly state what additional apparatus is needed, and indicating how the apparatus is set up. There were a significant number of candidates who did not seem to be aware of what alcohol burners are, or of the techniques that would be used. Others described the equipment correctly but did not clearly state that the temperature of the water and the mass of the burners needed to be taken both at the start and at the end of the heating. Some candidates described the equipment and the measurements but used 'energy change' and 'temperature change' interchangeably and did not clearly state that the alcohol with a higher temperature change per gram would release more thermal energy per gram.

CHEMISTRY

Paper 5070/32 Practical Test

Key messages

Candidates understanding of how to plan an experiment and how to record the level of detail required in an experimental plan is improving compared to previous years.

- It remains very important for candidates to take time to read the questions in detail before attempting to write their answers. A significant number of candidates do not obtain marks because they are not answering the question as set.
- When doing the practical tasks, candidates would benefit from looking back at their results to see whether their observations contradict each other. If time allows, they could then consider repeating and checking some parts. For example, if they obtain a red flame colour indicating lithium but then get results from the sodium hydroxide test that indicate calcium, it would be wise to redo the flame test to check whether the colour is red for lithium or orange-red for calcium.

Comments on specific questions

Question 1

- (a) Most candidates were able to complete this task. Some were not able to do the subtractions correctly, with a significant number subtracting the previous value in the temperature column rather than the initial temperature as they were instructed to do. Some candidates did not take note of the instruction to record all values to $\pm 0.5^{\circ}\text{C}$, for example recording 3 instead of 3.0. Candidates were awarded accuracy marks based on the maximum temperature change obtained by the Supervisor.
- (b) Credit for the graph was awarded with reference to the answers given by the candidates in (a). Candidates who had both positive and negative temperature changes in (a) found it more difficult to plot the graph. Candidates with incorrect values also found it difficult to draw an appropriate line of best fit to their points and a number resorted to joining the dots.
- (c) Candidates were awarded credit for a correct reading from a point of intersection even if this was in the wrong place.
- (d) Candidates find mole calculations difficult. Of those candidates who had an idea of how to do this calculation, the most common error was to use 25 instead of the volume of Y in (c).
- (e) Due to an issue with question 5(e), full marks have been awarded to all candidates for this question to make sure that no candidates were disadvantaged. The question has been corrected in the published version of the paper.
- (f) Most candidates were aware that a pipette is more accurate or precise than a measuring cylinder. Some candidates incorrectly thought that pipettes only measure a volume of 25 cm^3 .
- (g) Many candidates only said that the mixture was stirred to mix the chemicals, but this was insufficient. They needed to explain that the purpose of mixing was either to ensure an even temperature or to ensure a complete reaction.

Question 2

Throughout this question, candidates need to refer to the 'Notes for use in quantitative analysis' provided towards the end of the paper. Appropriate use of this data made answering this question more straightforward.

- (a) (i) Many candidates described the colour correctly. The most common incorrect answer was to describe the colour as red rather than orange-red. Candidates should use the data sheet provided to help them describe results appropriately. Where more than one ion gives a similar colour, it is important to use wording that clarifies the observation.
- (ii) Candidates should be aware that the flame produced with the air hole open on the Bunsen burner is yellow. Some candidates thought that the yellow colour referred to the presence of sodium. A yellow flame masks the colour of the flame test making it hard to see. Spirit burners are not appropriate for flame tests.
- (b) Some candidates used vague descriptions rather than the technical descriptions found on the data sheet. Terms such as 'cloudy' are not a suitable alternative to 'white precipitate'.
- (c) If candidates observed some white precipitate, they needed to state that it was 'slight', so as to correctly identify the calcium ion. Most candidates saw no change.
- (d) Credit was awarded for an appropriate conclusion made from the candidates' answers to previous questions and the data provided.
- (e) Many candidates correctly described a colour in the acid range. Many candidates thought the colour was purple.
- (f) It is important that candidates read the instructions fully. A significant number of candidates did not note that they needed to test and name any gases evolved.
- (g) Most candidates correctly described a white precipitate that remains insoluble in excess. Some thought that it dissolved in excess.
- (h) Most candidates correctly described a white precipitate.
- (i) Few candidates recognised that the results of the tests in (e) and (f) indicate the presence of H^+ ions from an acid. Many candidates did not recognise that the solution being tested in (g) was not the original solution **Q** but was the product of the reaction of **Q** with magnesium. Given that they are told that **Q** contains only one cation, they should not have suggested that calcium was a possible ion present in **Q**, as they had no evidence for this. Credit was awarded for an appropriate conclusion made from the candidates' answers to previous questions and the data provided.

Question 3

Candidates are steadily improving over the years in their ability to answer this type of free-response planning question.

The most important starting point for candidates is to look at the bullet points in the question where they are told what the plan should include. Some candidates, including those that performed well overall, omitted one or more of the sections.

Credit for apparatus could be awarded either in the text or in labelled diagrams. When naming apparatus, it is best practice to also state why the apparatus is needed. Credit is not awarded for every possible piece of apparatus but is targeted to the apparatus that is essential to the task.

Many candidates did not fully address the requirement to test the amount of thermal energy per gram.

Candidates could:

- Use the same mass of each metal and the same volume of acid and then compare the temperature changes in the experiment.
- Use measured masses of each metal and the same volume of acid and then divide the temperature change by the mass to make a conclusion about energy changes.
- Use the same mass of each metal and the same or variable masses or volumes of acid and use the formula $mc\Delta T$ to determine the energy change. Some candidates thought that the energy change was equal to temperature change $\div$ mass.

In all of these methods, both the initial and final temperatures needed to be measured.

Some candidates thought that the final temperature determined the energy change, but this only applies if the initial temperature is the same for both experiments.

Some candidates incorrectly thought they could dissolve magnesium and zinc in water before doing the rest of the experiment.

Some candidates incorrectly heated the mixture with a Bunsen burner and then measured temperature changes before and after heating.

CHEMISTRY

Paper 5070/41 Alternative to Practical

Key messages

Question 1 – Most candidates were familiar with the theory of fractional distillation but were less familiar with the equipment used and the reasons behind the equipment choices.

Question 2 – Candidates need to carefully read the question stem to clearly understand the task. Some candidates did not follow the instructions given in the question. Candidates should reflect on values they attain. If the values do not give the pattern indicated in the question, then they should double-check their work.

Question 3 – Candidates need to make full use of the ‘Notes for use in qualitative analysis’ sheets at the rear of the question booklet.

Question 4 – A number of candidates seemed unfamiliar with the use of alcohol burners. Candidates should be able to apply their practical skills even with unfamiliar contexts.

General comments

Most candidates attempted all of the questions, with very few omissions throughout the paper. Many candidates showed high levels of practical knowledge.

Candidates need to keep in mind that the wording of the question stems is there to help them. They should read the information given in the question paper carefully before attempting the questions. This was particularly relevant in **Questions 2(a), 2(b), 3(b) and 4**.

For **Question 3**, candidates should have used the ‘Notes for use in qualitative analysis’ pages. They are advised that even if they think they know the observation and result, they should double-check by referring to these notes.

Question 4 relied on the careful reading of the question, but also on a well-organised answer. Candidates should use the bullet-pointed statements as a guide to what they need to include in their answer.

Comments on specific questions

Question 1

- (a) The majority of candidates were able to correctly name the apparatus labelled **A** as a condenser.
- (b) Candidates were asked to describe the mistake in the set-up of the apparatus as shown in Fig. 1.1. Most candidates incorrectly stated that the condenser was the wrong way around. Very few appreciated that the technique would not work if the system was sealed and that the mistake shown was the stopper being in the conical flask.
- (c)(i)(ii) Both parts of this question were answered very successfully. Most candidates could identify that this was an example of fractional distillation and that it is the different boiling points of the substances that allow them to be separated in this way.

- (d) Fig. 1.1 only shows the heat being applied as an arrow. This question asked candidates to state which piece of apparatus would be used to provide the heat, and to explain why it is suitable. The highest achieving candidates stated that an electric heater should be used as the petroleum is flammable. Other candidates gave the answer 'Bunsen burner', not appreciating the flammability of the substances. Some candidates recognised that petroleum is flammable, but recommended the use of a water bath, which would not give a high enough temperature for the separation.

Question 2

Candidates were given the details of an experiment on temperature changes of a neutralisation reaction.

- (a) Most candidates correctly read the values shown on the thermometers in Fig. 2.1 as 23.5 °C and 29.0 °C. Most candidates also gave all of the temperatures and temperature changes to .0 °C or .5 °C. Some missed the '.0 °C' for whole number values, such as 29.0. Most candidates successfully calculated all the temperature changes. However, a significant minority calculated the values incorrectly, often by subtracting the previous temperature, rather than the initial temperature. The method candidates should follow was described in the question stem. Better performing candidates take their time and carefully read the instructions.
- (b) Candidates needed to correctly plot a graph of their values of temperature changes from (a). The y-axis needed to be labelled 'temperature change / °C'. While most candidates gave the correct label, some candidates omitted the units. A linear scale on the y-axis was also needed. This scale had to be sufficient for all of their values to be plotted and for the points to occupy at least half of the graph paper grid. Accurate plotting of the candidate's temperature change values to $\pm$ half a small square of the correct position was then needed. Candidates were then required to draw two lines of best fit. While the lines were dependent on the candidate's values, instructions were given in the question stem. Finally, an intersection point between the two lines of best fit was needed. The main problem for candidates who performed less well seemed to be in plotting temperature changes that were incorrectly calculated in **Question 2(a)**. Error carried forward marks were available, but when the incorrect candidates' values were negative and positive, it made writing the scale, and drawing the lines of best fit, more difficult. Candidates should be encouraged to consider their values, and if the graph is not plotting as they would expect, they should reconsider their calculations to see if errors have been made earlier.
- (c) The majority of candidates correctly determined the volume of **Y** where their two lines crossed, by reading the value from the x-axis.
- (d) Candidates were given the concentration of sodium hydroxide, 1.60 mol/dm³, and its volume, 25.0 cm³. They were asked to calculate the number of moles. Most candidates correctly converted the volume to dm³, then multiplied the two values together to give 0.04 moles.
- (e) Candidates were required to calculate the concentration of hydrogen ions in **Y**. They were instructed to use their answers to (c) and (d) in their calculation. Approximately half of the candidates were successful in this question. Better performing candidates correctly divided their value for (d) by their reading of the intersection point, (c), (converted to dm³).
- (f) The majority of candidates successfully recognised that a burette is used as it is more accurate than a measuring cylinder.
- (g) Candidates were asked why the temperatures are recorded after 30 seconds, rather than immediately. The best responses realised that this is to allow the temperature to reach its maximum. Candidates could also have suggested this would allow a complete reaction to occur. Many candidates stated that it is for the reaction to occur but did not specify that the 'complete' or 'full' reaction needs to occur.

Question 3

Candidates should have remembered to make full use of the 'Notes for use in qualitative analysis' sheets at the rear of the question paper.

- (a) Part (a) refers to the tests and observations in Table 3.1.
- (i) Candidates were told that solution **Q** is acidic. Table 3.1 states that in test 1 universal indicator is added, and it changes colour. Most candidates correctly identified that the expected colour change would be a change to red, indicating that the solution is acidic.
 - (ii) In test 2, a piece of magnesium was added. Candidates were told that the magnesium disappeared and were asked to predict one other observation. Most candidates were able to state that bubbles would be produced (or that the test-tube would get hot). Other candidates did not appreciate the 'other' in the question stem and simply repeated that the magnesium would dissolve. Candidates should be reminded that 'gas produced' is not an observation; they need to refer to how they could tell a gas is produced, e.g. seeing bubbles, fizzing, or effervescence.
 - (iii) Candidates were asked to predict what gas would be produced in test 2 (the addition of magnesium to an acidic solution). Approximately half of the candidates successfully identified that hydrogen would be produced.
 - (iv) Candidates were asked to describe the test to confirm the identity of the gas which they identified in (a)(iii). As hydrogen was the gas in (iii), the correct test and result are that hydrogen 'pops' with a lighted splint. This information is in the 'Notes for use in qualitative analysis' sheets at the back of the paper. The majority of candidates were successful with this question, but candidates should be reminded to use the information pages, even if only to check their answers, this would remove some of the minor mistakes which occurred.
 - (v) This question asks candidates to identify the cation and anion in **Q**. The majority of candidates correctly answered this question. Using the question stem, candidates should have realised that, as **Q** is acidic, hydrogen, H^+ cations, would be present. To identify the anions, candidates should have used the information on Table 3.1 for test 3. The table stated that when nitric acid and silver nitrate were added, a white precipitate was observed. Looking up this table in the 'Notes for use in qualitative analysis' pages would indicate that the test is for a halide anion, and that the white precipitate indicates the presence of a chloride, Cl^- ion. Some candidates correctly identified the test, but then stated it was indicative of a chlorine anion, rather than a chloride anion.
- (b) Part (b) refers to the tests and observations in Table 3.2.
- (i) Candidates were asked how to perform a flame test. The majority of candidates had an idea of how to do this, but only half the candidates achieved full credit. The best responses indicated that a wooden splint would be dipped into the solution and then held in the blue, roaring flame of a Bunsen burner. Some candidates identified that a splint should be put in the solution, then did not specify that it needs to be a blue flame on the Bunsen burner. Some candidates did not appear to know how to do a flame test and incorrectly stated that the solution in a beaker should be put over a flame.
 - (ii) This question asked for an additional observation expected in test 5, based on the observations in Table 3.2. Test 4 indicated that a blue-green flame was produced from a flame test. Candidates should have looked at the 'Notes for use in qualitative analysis' sheets and identified that the cation would be copper. Test 5 then indicates that excess ammonia was added, and it gives two observations. Candidates should then have looked at the 'Tests for aqueous cations' table and read about the effect of aqueous ammonia on copper ions. The 'Tests for aqueous cations' table states three observations; the one that is not in Table 3.2 is that a dark blue solution is produced. Approximately half of the candidates gave the correct answer. Other candidates needed to remember to make full use of all of the information provided to them.

- (iii) Candidates were asked to describe one additional test to confirm the identity of the cation in **R**. Most candidates correctly stated that sodium hydroxide should be added, giving a light blue precipitate which is insoluble in excess sodium hydroxide. As with **Question 3(b)(ii)**, all of the information needed is on the 'Tests for aqueous cations' table. Some candidates described a flame test, or an aqueous ammonia test, but the question states 'one additional test'; since both of these tests are already mentioned on the table, these answers were not allowable.
- (iv) Most candidates correctly identified the cation as copper, Cu^{2+} .

Question 4

The question stem shows the candidates a diagram of an alcohol burner. Candidates are told that alcohols are used as fuels to heat water. They are asked to plan an experiment using an alcohol burner to investigate whether methanol or ethanol releases more thermal energy per gram of alcohol burned. The bullet points in the 'Your plan should include' section, indicate statements candidates needed to address.

Better performing candidates gave a plan which included the use of a measuring cylinder, thermometer, balance and a suitable container to heat water in, e.g. a beaker. They stated that the mass of the alcohol burner would be measured before and after heating the water, that the same volume of water would be used for both alcohols, and that the temperature of water would be measured before and after burning the alcohol. To determine which alcohol releases more thermal energy per gram, these candidates stated that the temperature change should be divided by the mass change to give the temperature change per gram. Finally, they indicated that the alcohol with the higher temperature change per gram would be the alcohol that releases more thermal energy per gram burned. Approximately half the candidates successfully described this method.

It was common for candidates to correctly state what additional apparatus is needed, and indicate how the apparatus is set up. There were a significant number of candidates who did not seem to be aware of what alcohol burners are, or of the techniques that would be used. Others described the equipment correctly but did not clearly state that the temperature of the water and the mass of the burners needed to be taken both at the start and at the end of the heating. Some candidates described the equipment and the measurements but used 'energy change' and 'temperature change' interchangeably and did not clearly state that the alcohol with a higher temperature change per gram would release more thermal energy per gram.

CHEMISTRY

Paper 5070/42 Alternative to Practical

Key messages

- Candidates understanding of how to plan an experiment and how to record the level of detail required in an experimental plan is improving compared to previous years.
- It remains very important for candidates to take time to read the questions in detail before attempting to write their answers. A significant number of candidates do not obtain credit because they are not answering the question as set.

Comments on specific questions

Question 1

- (a) Most candidates knew this to be a conical flask. Some candidates incorrectly referred to it as a 'beaker'. Simply calling it a 'flask' was insufficient.
- (b) The context of the question was about adding a fixed volume of acid, so candidates needed to mention a piece of apparatus suitable for measuring a volume, not just a generic piece of equipment that is used in most experiments.
- (c) Many candidates recognised that the new cross would be different each time it was drawn. However, fewer candidates realised that it was the thickness or darkness of the cross that would affect the accuracy. Even fewer candidates were able to recognise that a change in the darkness of the cross would affect the time taken for it to no longer be visible.
- (d) Many candidates referred to the rate of reaction rather than the time taken. The question explicitly asked for the effect on the time so writing about rate alone was insufficient. Some candidates incorrectly thought that if the rate increases then the time also increases.
- (e) Many candidates referred to the use of masks. A standard face mask would not be effective and a specialised gas mask is not appropriate for a simple laboratory experiment. Few candidates were familiar with the use of a fume cupboard. Credit was given for referring to adequate ventilation in the laboratory.

Question 2

- (a) Most candidates could read the temperatures from the diagrams. Many candidates were not able to do the subtraction correctly, with a significant number subtracting the previous value in the temperature column rather than the initial temperature as they were instructed to do. Some candidates did not take note of the instruction to record all values to $\pm 0.5^{\circ}\text{C}$, for example recording 3 instead of 3.0.
- (b) Credit for the graph was awarded with reference to the answers given by the candidates in (a). Candidates who had both positive and negative temperature changes in (a) found it more difficult to plot the graph. Candidates with incorrect values also found it difficult to draw an appropriate line of best fit to their points and a number resorted to joining the dots.
- (c) Candidates were awarded credit for a correct reading from a point of intersection even if this was in the wrong place.

- (d) Candidates find mole calculations difficult. Of those candidates who had an idea of how to do this calculation, the most common error was to use 25 instead of the volume of **Y** in (c).
- (e) Some candidates did not take note that concentration needed to be expressed in mol/dm³ not mol/cm³.
- (f) Most candidates were aware that a pipette is more accurate or precise than a measuring cylinder. Some candidates incorrectly thought that pipettes only measure a volume of 25 cm³.
- (g) Many candidates only said that the mixture was stirred to mix the chemicals, but this was insufficient. They needed to explain that the purpose of mixing was either to ensure an even temperature or to ensure a complete reaction.

Question 3

Throughout this question, candidates needed to refer to the 'Notes for use in quantitative analysis' provided towards the end of the paper. Appropriate use of this data made answering this question more straightforward.

- (a) (i) Candidates have improved in their ability to answer questions on how to perform a flame test. However, many candidates are still unaware of the importance of using a roaring or blue flame so that the colour caused by the ion is not masked by a luminous or yellow flame.
 - (ii) Many candidates realised that an orange-red flame indicated the presence of calcium and were able to give the correct observation for the addition of ammonia to a solution containing calcium ions.
 - (iii) Many candidates were then able to correctly describe the effect of aqueous sodium hydroxide on calcium ions.
 - (iv) Many candidates were able to correctly identify calcium ions as the cation in **P**.
- (b) (i) Many candidates were able to describe the colour change universal indicator is added to acidic solution.
 - (ii) Candidates should be aware that if a gas is produced in a solution, they will observe effervescence.
 - (iii) Many candidates were aware that hydrogen is formed when an acid reacts with magnesium.
 - (iv) Credit was awarded here for the correct test and result for the gas the candidates had named in (a)(iii). If they had named a gas other than hydrogen in (a)(iii), then they did not gain credit for the test for hydrogen. The test had to match the gas they thought had been produced.
 - (v) Credit was awarded for appropriate conclusions made from the candidates' answers to previous questions and the data provided.

Question 4

Candidates are steadily improving over the years in their ability to answer this type of free-response planning question.

The most important starting point for candidates is to look at the bullet points in the question where they are told what the plan should include. Some candidates, including those that performed well overall, omitted one or more of the sections.

Credit for apparatus could be awarded either in the text or in labelled diagrams. When naming apparatus, it is best practice to also state why the apparatus is needed. Credit is not awarded for every possible piece of apparatus but is targeted to the apparatus that is essential to the task.

Many candidates did not fully address the requirement to test the amount of thermal energy per gram.

Candidates could:

- Use the same mass of each metal and the same volume of acid and then compare the temperature changes in the experiment.
- Use measured masses of each metal and the same volume of acid and then divide the temperature change by the mass to make a conclusion about energy changes.
- Use the same mass of each metal and the same or variable masses or volumes of acid and use the formula $mc\Delta T$ to determine the energy change. Some candidates thought that the energy change was equal to temperature change $\div$ mass.

In all of these methods, both the initial and final temperatures needed to be measured.

Some candidates thought that the final temperature determined the energy change, but this only applies if the initial temperature is the same for both experiments.

Some candidates incorrectly thought they could dissolve magnesium and zinc in water before doing the rest of the experiment.

Some candidates incorrectly heated the mixture with a Bunsen burner and then measured temperature changes before and after heating.