CHEMISTRY

Paper 5070/11
Multiple Choice

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

<u>Comments on specific questions</u>

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

Question 8

Option **A** is the chemical formula most familiar to candidates. This may explain why it was chosen most often by candidates who didn't use the information to work out the reaction stoichiometry.

Question 9

All options were commonly selected. Candidates had to recall the formula of sodium sulfate, calculate the *M*r and then work through the calculation. Option **A** was chosen by those candidates who did not use the stoichiometry of sodium in sodium sulfate.

Question 12

Candidates choosing option **C** have given the correct answer for *inert* electrodes, whereas the question specifies *copper* electrodes.

Question 13

Some evidence of guessing was seen in this question. A popular incorrect option was **D**. This suggests that hydrogen-oxygen fuel cells, is not a well known topic by candidates, specifically that hydrogen and oxygen are **not** burned in the fuel cell.

Question 14

The majority of candidates chose option **A** or option **B**. These candidates did not understand that activation energies are positive values.

Question16

Candidates performed poorly on this question, which suggests that physical and chemical changes are not well known by candidates.

Question 17

Some candidates missed an important detail. In method 2, while the experimental set-up is valid, only one reading is taken and so will not show how the rate of reaction *changes*.

Question 21

All options were commonly selected and candidates performed poorly on this question, which suggests that the topic of oxides is not well known.

Question 22

The majority of candidates chose option **A**, suggesting poor knowledge of solubility rules of chlorides and carbonates.

Question 29

While electrolysis could be used for the extraction of all the metals shown, candidates were expected to know that it is **not** used to extract iron from hematite.

Question 39

Option **B** was a popular incorrect choice. Candidates selecting this option confused the use of the term *saturated* when applied to hydrocarbons with a saturated solution.

CHEMISTRY

Paper 5070/12
Multiple Choice

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

Comments on specific questions

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

Question 8

There was some evidence of guessing on this question. Candidates did not use the information supplied to work out the reaction stoichiometry. Options **A** and **D** were both commonly seen.

Question 11

The majority of candidates chose option **B**, which is simply $(50 \div 80) \times 100$. These candidates did not apply correct chemistry, such as use of atomic and formula masses.

Question 14

Option **D** was a popular incorrect choice. Candidates did not apply the idea of a limiting reagent to the question and so had a value twice the correct answer.

Question 15

The majority of candidates chose option **C** or option **D** This suggests that physical and chemical changes are not well known by candidates.

Question 22

The majority of candidates chose option **A** or option **B**. This suggests poor knowledge of the solubility rules of chlorides, nitrates and sulfates.

Question 24

A common misconception was to think that strength of covalent bonds, rather than intermolecular forces, determine boiling points in Group VII, which explains why option **D** was a popular incorrect choice.

Question 29

Candidates choosing options **A** or **B** did not take into account that *solid* substances, as in statement 1, cannot be electrolysed.

Question 30

Candidates who selected option **A** incorrectly thought that distillation is used to separate insoluble impurities from water.

Question 33

The majority of candidates chose option **D**. Candidates did not know the arrangement of atoms and bonding in the –COOH functional group.

Question 36

There was evidence of guessing by some candidates. Candidates had to use knowledge from three different parts of the syllabus,10.3.8, 11.6.1(a) and 11.7.2, to work out the answer.

Question 37

Candidates had correctly deduced that Y is a polyester but did not understand how to deduce the repeat unit of the polymer from the given monomer.

Question 38

Candidates performed poorly on this question, which indicates they had poor knowledge of the terms described in 12.1.3 of the syllabus, e.g., solvent, solute, residue.

CHEMISTRY

Paper 5070/21
Paper 2 Theory 21

Key messages

- Candidates need to read questions carefully so that they answer fully what is being asked, e.g. **Question 3(c)** where the candidates often did not state that the rate of the reaction was faster.
- Candidates need more practice constructing balanced equations, particularly ionic equations.
- Many candidates could not name the products of electrolysis or construct the relevant half ionic equations.

General comments

Candidates were generally well prepared for this examination and had sufficient time to complete the paper; some of the more demanding questions were omitted by some candidates.

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

Some candidates confused oxidising agent and oxidation. Construction of equations proved difficult. The products of electrolysis, organic chemistry and structure and bonding were not well known.

Comments on specific questions

Question 1

(a) Carbon monoxide was very well known. Carbon dioxide was the common incorrect response.

(b) The chemical test for water was well known. Common incorrect responses included calcium oxide, sodium sulfate, lead chloride and sulfur dioxide.

(c) Candidates found identifying the nitrate difficult. Carbon dioxide, sulfur dioxide, carbon monoxide, sodium sulfate and calcium oxide were all common responses.

(d) The sulfate test was quite well known. Sulfur dioxide, calcium oxide, carbon monoxide and sodium nitrate were common incorrect responses.

(e) The anion with a 1– charge was well known. Sodium sulfate was the common incorrect response.

Question 2

(a) Many candidates recalled one or two physical properties which were different between the two metals. Many chose physical properties which were similar such as malleable and ductile or gave chemical properties such as catalysis, variable oxidation states, reaction with water or coloured compounds.

(b) The electronic configuration was well known by the majority of candidates. Incorrect responses included 1–, 2+, 2.8.8.1, 2.8.7, 4.8.8. and 2.8.9.

(c) The majority of candidates interpreted the data correctly to achieve a correct order of reactivity. A small number had uranium more reactive than vanadium.

(d) Almost all candidates surmised the numbers of protons and neutrons correctly. Common incorrect responses included 32, 65 and 36 for the number of protons and 65 and 29 for the number of neutrons.

(e) Candidates found this equation very challenging. Most did not include oxygen as a reactant or gave the formula as O. Copper was often Cu_2. Common products included CuO and Cu_2SO_4.

(f) (i) Lowering of activation energy was known by better performing candidates. Many others repeated the question stem by stating they speed up a reaction. 'Alternative pathway' was insufficient.

(ii) The catalyst was quite well known. Common incorrect responses included vanadium(II) oxide, vanadium oxide, phosphoric acid and iron. A small number omitted the question.

(g) Good electrical conductivity was well known; a second reason proved more difficult. Malleable, high melting point, non-corrosive, cheap and non-conductor of electricity were common incorrect responses.

Question 3

(a) State symbols were very well known. A small number gave (l) for HC*l*.

(b) (i) Almost all candidates read the graph correctly. A small number gave 50 seconds.

(ii) Candidates found this quite challenging. Many gave less steep lines, with the final volume often greater or sometimes smaller than the original. A small number omitted the question.

(c) Most candidates appreciated that the reaction would be faster. The increase in kinetic energy of the particles was well known. Some discussed the reactants gaining kinetic energy or referred to a general increase in energy or thermal energy. Whilst many appreciated there would be more collisions, a high proportion of candidates did not discuss either more successful/effective collisions or more particles having energy greater than or equal to the activation energy.

(d) Candidates found this very difficult. Many thought the particles would gain kinetic energy or discussed pressure being proportional to volume or an increased number of collisions with the wall of the container.

Question 4

(a) Products of electrolysis were not well known. At the anode common incorrect responses included bromide, calcium, Br^- and Ca^{2+}, and at the cathode calcium and bromide.

(b) Candidates found ionic half equations very difficult. $Br^- \rightarrow Br + e^-$, $Br_2 \rightarrow 2Br^- + 2e^-$, $2Br^- + 2e^- \rightarrow 2Br$ and $2Br^- + 2e^- \rightarrow Br_2$ were common anode equations and $Ca^{2+} + 2e^- \rightarrow 2Ca$, $Ca^+ + e \rightarrow Ca$, $Ca^{2+} \rightarrow 2Ca + 2e^-$, and $H^+ + e^- \rightarrow H$ were common cathode equations. A small number omitted the question.

(c) The test for bromide ions was not well known. Incorrect responses included: alkene with the bromine turning colourless form brown; sodium hydroxide giving a white precipitate and barium nitrate. Yellow precipitate was also common.

(d) (i) Candidates found this very challenging. Many confused oxidising agent and oxidation and so thought calcium gained electrons or thought zinc gained the electrons rather than zinc ions.

(ii) Many candidates gave 2 rather than +2.

(e) Many candidates drew 2 correct single bonds between the S and Br; some put 3 or 4 electrons into each bond. The non-bonding electrons proved more difficult with many either omitting them altogether or putting 5 instead of 6.

Question 5

(a) (i) Many candidates appreciated that the functional group is the C=C. Incorrect responses included: C-O, O-H, C_2H_5 and COOH.

(ii) Candidates found this quite challenging. Many gave either C_5H_7COOH or a full structural formula.

(iii) Many candidates described the motion of the particles as vibrating. Common incorrect responses included no movement or description of a liquid. The arrangement proved more difficult with many describing the proximity of the particles rather than their ordered or regular nature.

(b) (i) Addition was well known. All types of reaction were seen with substitution being the most common.

(ii) The catalyst was not well known. Common responses included: iron; vanadium pentoxide; phosphoric acid; oxygen; water; hydrogen and potassium permanganate. A significant number omitted the question.

(c) Candidates found this very difficult. Many gave structures including a C=C double bond, CH_3 in the chain backbone or had 2-valent hydrogen atoms or no continuation bonds. Some omitted the question.

(d) (i) Amino acid was not well known. Common responses included: amide; carboxylic acid and nylon. A significant number omitted the question.

(ii) Common incorrect responses included nylon and ester. A significant number omitted the question.

Question 6

(a) (i) The percentage of nitrogen in the air was well known. 79%, 21% and 80% were popular responses.

(ii) The source of hydrogen was quite well known. Air and ammonia were popular responses. A small number omitted the question.

(b) (i) Candidates found this very difficult with many either only discussing bond making or describing bond making as using energy. A small number omitted the question.

(ii) The symbol was quite well known. Common incorrect responses included ΔH with no sign, ΔE and ΔH+. A small number omitted the question.

(c) (i) The name of the salt was well derived. Common incorrect responses included ammonia nitrate, ammonium and nitrogen hydroxide. A small number omitted the question.

(ii) Better performing candidates knew the name of the technique. Neutralisation, filtration, precipitation and crystallisation were popular responses. A significant number omitted the question.

Question 7

(a) Many candidates gave a fully correct calculation; others omitted to include the stoichiometry of the equation. Some thought the volumes referred to gases and so either multiplied or divided by 24 000 and some attempted to calculate number of moles using mass ÷ M_r.

(b) The colour was not well known. Colourless, pink and yellow were popular responses.

(c) (i) The term weak was well known. Incorrect responses included: dissolved instead of dissociated; has few H^+ or has a high pH.

(ii) The ion was quite well known. OH^- was a popular response as was the neutralisation equation $H^+ + OH^- \rightarrow H_2O$.

(d) Better performing candidates calculated the value correctly. The calculation of M_r proved to be difficult for many. Some multiplied by 24 but left the unit as cm^3; some divided by 24. A significant number omitted the question.

(e) (i) Better performing candidates named a correct source of sulfur dioxide. Incorrect sources included cars, decomposition, lightning, industry, fertilisers, Contact process and combustion of sulfur. A small number omitted the question.

(ii) Candidates found this very challenging. Incorrect responses included catalytic converters, stop industries and stop burning sulfur. A small number omitted the question.

(iii) Better performing candidates correctly completed the equation. SO_4, $2SO_4$, $SO_2 + O_2$ and $2S + O_2$ were popular responses. A small number omitted the question.

Question 8

(a) (i) Better performing candidates explained the effect on the position of equilibrium. Favouring the left is insufficient for the equilibrium moving to the left. Common incorrect responses included: move to the right as there are moles of gas there; move to the right because it is exothermic and no change.

(ii) Candidates found this difficult. Many thought the equilibrium moved to the left because there were either more or less molecules there. A small number omitted the question.

(b) The alcohol was well known although propanol and butanol were quite popular. The oxidising agent was less well known with popular responses including oxygen, potassium(II) manganate, potassium(IV) manganate, potassium manganate, potassium dichromate(IV), potassium iodide and yeast. A small number omitted the question.

(c) Naming the ester proved quite difficult. Incorrect responses included ethyl ethanoate, propyly ethanoate, ethanol ethanoate and names including the acid or the alcohol. The displayed formula proved to be very difficult with many 2-valent linking hydrogens, C-O dangling from a structure, alcohols and acids. A small number omitted the question.

Question 9

(a) (i) Candidates found this very challenging with few creditworthy responses. Many described magnesium as having ionic bonding, covalent bonding or intermolecular forces and phosphorus as having a simple covalent structure with no further information, ionic bonding or weak covalent bonding. Some only stated that magnesium is a metal and phosphorus a non-metal or that magnesium has stronger forces than phosphorus. Some discussed electrical conductivity.

(ii) Candidates found this challenging. Many discussed delocalised electrons or free electrons without mention of them being mobile. 'Magnesium is a metal and phosphorus a non-metal' and 'graphite is giant covalent and phosphorus is not', were common non-creditworthy responses.

(b) Candidates found this very difficult. Some discussed the strong covalent bonding in diamond without an indication of the network of bonds or discussed the layers in graphite with no mention of diamond. Some thought that diamond contained intermolecular forces.

(c) The majority of candidates deduced the empirical formula correctly. Some candidates used atomic numbers, mixed up the percentages, used K for phosphorus, C for chlorine or divided by 32 for oxygen or 71 for chlorine.

CHEMISTRY

Paper 5070/22
Paper 2 Theory

Key messages

- Candidates must be able to distinguish between the key ideas related to chemical equilibria and rate of reaction. Answers involving chemical equilibria should not use collision theory and answers involving rate of reaction should not include arguments about the position of equilibrium.
- Candidates should ensure that they give the name of a substance if asked for the name and a formula if asked for a formula in the question. Even if the question asked to identify a substance, candidates should be advised it is better to give the name since they are less likely to get the formula correct.
- Candidates find questions relating to structure and bonding very difficult and often use contradictory terms in their answers, e.g. intermolecular forces with giant ionic or covalent structures.

General comments

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

In quantitative questions, some candidates did not show sufficient working out so it was not always possible to award error carried forward marks.

Comments on specific questions

Question 1

Almost all the candidates followed the rubric and gave the name of the compound rather than the formula.

(a) Many candidates chose methane but ammonia and nitrogen dioxide were common incorrect answers.

(b) The test for water was not well known and phosphorus(V) chloride was a common error.

(c) Many candidates recognised that water reacts with ethene to make ethanol. Some candidates gave steam and this was credited. A common error was poly(ethene).

(d) Glucose was well known as a product of photosynthesis.

(e) Candidates gave lots of different answers including covalent molecules such as nitrogen dioxide and the ionic salts magnesium chloride and sodium bromide.

Question 2

This question was about different metals.

(a) Some candidates could not distinguish between chemical and physical properties often referring to chromium having coloured compounds and having varying oxidation states in its compounds. The most common answers referred to chromium being hard and having a high density. Candidates did not need to give comparative answers but had to make it clear if the property was related to chromium or sodium.

(b) Many candidates were able to deduce both the correct number of protons and neutrons. Candidates were more likely to get the number of protons correct then the number of neutrons. The most common errors for the number of neutrons were 53 and 77.

(c) Candidates found constructing this equation very challenging. Typical errors were writing chlorine as Cl and carbon as C_2. Other candidates gave carbon dioxide as the product rather than carbon monoxide.

(d) Candidates were often able to draw the electronic configuration of a sodium ion. The most common error was an incorrect ionic charge such as Na^{2+} or Na^{-} or to leave the charge blank.

(e) Candidates were often able to deduce the correct order of reactivity but some candidates reversed the order.

(f) (i) Candidates often appreciated that the surface of aluminium is covered in an oxide layer but were unable to explain how this makes aluminium resistant to corrosion. The most common answer was that it stops reaction with either oxygen or water, rather than the layer acting as a protective barrier stopping water or oxygen reaching the surface of the aluminium. The most concise answers referred to either a non-permeable oxide layer or a non-porous oxide layer.

(ii) The most popular answers were low density and good electrical conductivity. Some candidates ignored the reference to other reasons and referred to the lack of corrosion. A number of candidates thought that aluminium had a poor electrical conductivity. Lightweight was not accepted instead of density.

Question 3

This question involved an investigation about the reaction between calcium carbonate with dilute hydrochloric acid.

(a) Candidates were often able to identify at least one state symbols. Common errors were $HCl(l)$ instead of $HCl(aq)$ and $H_2O(aq)$ rather than $H_2O(l)$. Some candidates wrote the state symbols using upper case rather than lower case.

(b) (i) Most candidates were able to interpret the graph.

(ii) A significant proportion of the candidates did not end their line at $46\,cm^3$, other candidates did not appreciate that that gradient of the line was greater than the original. Some candidates did both of these errors. Some candidates did not show sufficient differentiation between the original line and their line and as a result it was not possible to assess if the gradient was greater than the original or the same. Other candidates did not start the line at the origin but started some way up the *y*-axis. A small but significant proportion of the candidates did not attempt the question.

(c) Not all the candidates appreciated that the temperature had decreased and referred to the rate of reaction increasing. Candidates had to refer to the particles having less kinetic energy or that the particles were moving slower. A common misconception was that particles gained less kinetic energy when in fact they would lose kinetic energy since the temperature decreased. Responses had to refer to fewer successful collisions or fewer effective collisions. Answers that just mentioned collision frequency were not awarded credit.

(d) The idea that the particles would be closer together and that there were more particles per unit volume were the most common answers. Some candidates approached this question in terms of rate of reaction and referred to collisions between particles. This approach was not given any credit.

Question 4

Candidates found the questions about electrolysis very challenging.

(a) Some candidates gave ionic half-equations for the electrode reactions, most of which were incorrect. Other candidates gave formulae, more often than not these were not correct. For example, giving ions or monoatomic iodine. Iodine as the product at the anode was the most common correct product and magnesium as the product at the cathode was the most common incorrect answer.

(b) Candidates were often unable to write the correct ionic half-equations. Typical errors included the incorrect products, incorrect formulae such as Mg_2 and electrons on the wrong side of the equation. A small but significant proportion of the candidates did not attempt the question.

(c) The formation of a yellow precipitate in the test for iodide ions was quite well known but often the reagents given were incorrect. Those candidates that did mention the use of an acid with aqueous silver nitrate often used nitric acid. A small but significant proportion of the candidates did not attempt the question.

(d) (i) Candidates did not always use the correct particle in their answers, for example 'iodine loses electrons' rather than iodide loses electrons. Some candidates referred to hydrogen ions gaining electrons rather than the manganese in MnO_2 gaining electrons. Other candidates gave answers that referred to electron gain rather than electron loss.

(ii) Redox was a common answer but some candidates referred to reversible or neutralisation.

(e) Candidate were often able to get the bonding pairs correct but struggled to get all the non-bonding electrons correct. Candidates did not need to draw the non-bonding electrons as pairs but it might help some candidates to ensure they include the correct number of electrons.

Question 5

This question was about alkenes and plastics.

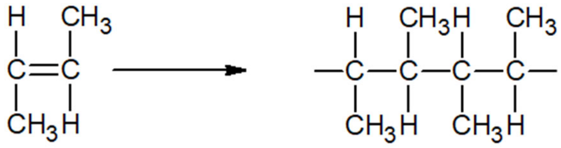
(a) (i) Candidates were often able to identify the functional group. Some included the hydrogen atoms attached to the carbon atoms of the double bond and this was not given any credit. A small proportion of the candidates circled the hydroxyl group. A small but significant proportion of the candidates did not attempt the question..

(ii) The colour change with aqueous bromine was well known.

(iii) A significant proportion of the candidates did not appreciate that a molecular formula just shows the number and type of atom in a molecule. Many candidates included aspects of structure in their answers for example the –O—H group or OH in the formula.

(iv) Some candidates misunderstood the word separation and gave methods of separation in their answer such as fractional distillation and filtration. A common misconception was that particles in a liquid were spread out rather than being very close together. In terms of motion, the best answers referred to particles moving past each other.

(b) Many candidates found this question very challenging. A common answer was to draw a structure that resembled four repeat units of ethene. Displayed or structural formula or a mixture of both were allowed. Centres should advise candidates to draw the structure of the alkene and the addition polymer as shown since it is easier to see how the polymer is formed.



A significant proportion of the candidates did not attempt the question.

(c) The three environmental challenges in the syllabus were given credit along with the idea that plastics are non-biodegradable or took a long time to decay or decompose. Candidates that mentioned only land pollution, air pollution and water pollution were not given credit since there had to be some more detail in their descriptions. Air pollution had to be linked with incinerating plastics and forming a known atmospheric pollutant or a toxic gas; land pollution had to be linked to the need for landfill sites and water pollution to accumulation of plastic in sea or oceans, blocking of sewage pipes or killing marine organisms.

Question 6

This question was about carbon monoxide and hydrogen.

(a) (i) The best answers stated that bond breaking absorbs energy and bond making releases energy and then went on to state that more energy is absorbed than released. The most common misconception involved more energy needed for bond breaking than bond making.

(ii) Candidates gave a wide range of answers for the symbol for an endothermic reaction including $H+$, $H+$, $\Delta H+$, $+\Delta H$ and $\Delta H>0$. The best answers was ΔH = positive or +ve.

(b) (i) Carbon and soot were rarely mentioned by candidates and the most common answers were pollutants such as oxides of nitrogen. A small but significant proportion of the candidates did not attempt the question.

(ii) The toxic nature of carbon monoxide was well known. Common misconceptions included it is a greenhouse gas; it causes corrosion and causes cancer.

(c) Candidates often stated that water was formed but rarely mentioned that water was the only product. A common misconception was that no greenhouse gases were emitted even though water is a greenhouse gas. Some candidates appreciated that a hydrogen-oxygen fuel cell was more efficient that a petrol engine. Other candidates appreciated that hydrogen is a renewable fuel (if made from water). Candidates were often more likely to gain credit through reverse arguments when they wrote disadvantages of a petrol engine.

Question 7

This was about the reaction between dilute hydrochloric acid and aqueous sodium carbonate.

(a) The best answers gave detailed working out so it was possible to award error carried forward marks.

The best answers:

- calculated the amount in moles of sodium carbonate
- used the stoichiometry of the question to calculate the amount of HCl
- calculated the concentration of the HCl.

Typical errors involved omitting the stoichiometry or using the incorrect stoichiometry.

Candidates should be advised to quote their final answer to the minimum number of significant figures given in the data for the question. In this, case three significant figures was be appropriate.

(b) (i) Some candidates gave the colour as red or orange rather than yellow.

(ii) Candidates often wrote the correct formula of OH^- but some candidates wrote the ionic equation between a hydroxide ion and a hydrogen ion instead. A small but significant proportion of the candidates did not attempt the question.

(c) Many candidates did not calculate the correct amount in moles of sodium carbonate and typically used 44 rather than $106\,g\,mol^{-1}$ for the molar mass. The stoichiometric relationship between amount of sodium carbonate and the amount of carbon dioxide was rarely stated but often used in a calculation. Some candidates gave the answer in dm^3 rather than cm^3. A small but significant proportion of the candidates did not attempt the question.

(d) The definition of the term strong in a strong acid was well known.

(e)(i) The most popular adverse effects of oxides of nitrogen were photochemical smog, ozone depletion and global warming.

(ii) Candidates found completing this question quite challenging. Common errors included having nitrogen as N and writing strange formulas containing C, N and O. Some candidates gave carbon as one of the products.

Question 8

This question was about methanol.

(a) (i) Some candidates confused arguments about rate and position of equilibrium and sometimes just focused on rate. Candidates needed to describe the correct movement of the position of equilibrium. In this case, the position moves to the side of the products. In this question there was no need to refer to moles of gas since all the substances in the equilibrium were gases but there had to be a statement that the number of moles of products was less than that of the reactants. It was not sufficient just to state three moles make one mole.

(ii) Candidates were not always clear that the backward reaction was endothermic. Candidates should avoid giving statements such as the reaction moves to the endothermic side. The best answer would be 'the reaction shifts to the reactants since the backward reaction is endothermic'. A small but significant proportion of the candidates did not attempt the question.

(b) Candidates found drawing the displayed formula of methyl ethanoate challenging and some candidates drew structures that were ketones or had a hydroxyl group at the end of the chain. Candidates found it much easier to name the ester however, they needed to be careful with the correct spelling for ethanoate.

(c) Candidates were often able to list two general characteristics of a homologous series. The most common answers were that a homologous series has a general formula; the same functional group and similar chemical properties. Fewer candidates included a comment about each member varying by a CH_2 group or 14 atomic mass units. Common misconceptions included homologous series have the same structural formulae or they have similar general formula or functional group, rather than the same general formula or functional group. Candidates also gave answers that suggested physical properties were similar rather than they had an observable trend.

Question 9

This question was about the structure and bonding of three different elements and also included an empirical formula calculation.

(a) (i) Candidates found this question very challenging. Many candidates mentioned intermolecular forces when describing diamond even when they correctly identified the structure as giant molecular or giant covalent. The idea of a lattice with many strong covalent bonds was poorly expressed for diamond. In terms of iodine, the candidates were more likely to be awarded credit for weak intermolecular forces. A common answer was iodine had weak covalent bonds.

(ii) Many candidates referred to free electrons or delocalised electrons in their answers but did not mention that these electrons could move. A simple answer such as calcium has moving electrons and iodine does not have moving electrons was fully correct. Candidates sometimes referred to moving ions or molecules rather than electrons. Some candidates did not attempt an explanation and only stated that calcium was a metal and iodine was a non-metal.

(b) The best answers appreciated that graphite had a structure with layers and that the layers could slide over each other very easily. Some candidates focused on the delocalised electrons in graphite rather than mentioning layers. A small but significant proportion of the candidates did not attempt the question.

(c) Candidates were often able to calculate the correct empirical formula and included most of the relevant working out. Errors came from using the molar mass of iodine and oxygen as 254 and $32\,g\,mol^{-1}$ respectively or using the proton number rather than molar masses. Some candidates inverted their expression for calculating the amount in moles.

CHEMISTRY

Paper 5070/31
Paper 3 Practical Test

Key messages

- Care is needed when doing the experimental work to ensure correct results and observations are obtained.

General comments

Candidates need to make sure that they describe things in full. The number of marks allocated to a question often relates to the number of observations that need to be recorded.

Candidates need to make better use of the 'Note for use in qualitative analysis' data sheet provided.

Comments on specific questions

Question 1

(a) Candidates were able to complete the table of results. The instructions stated that the temperatures should have been measured to the nearest 0.5 °C, but some candidates did not record to this level of precision. Some candidates did not obtain the expected results or results comparable to the Supervisor. Most candidates calculated the temperature change correctly from their data.

(b) Most candidates were able to plot their points correctly. Some candidates had obtained unexpected results outside of the range of the grid provided. Candidates who had obtained expected results found it easier to draw lines of best fit. Candidates who had unexpected results were credited for lines of best fit which matched their data.

Some candidates found the concept of drawing two straight lines of best fit difficult, with a number of candidates drawing a single curve for all of the points and others drawing a third line rather than extending the lines to a point of intersection. Some candidates did dot to dot graphs.

(c) Where a point of intersection had been drawn, candidates generally read the value from the graph correctly.

(d) The most common error in this calculation was to use a value of 25 cm^3 instead of the value from **(c)**.

(e) Many candidates knew plastic is a better insulator, but fewer candidates went on to explain that this means there is less energy transferred to the surroundings in the experiment.

(f) It was encouraging that many candidates were familiar with the idea of the precision of a piece of measuring equipment in relation to the number of decimal places to which the scale can be read.

Question 2

(a) A white precipitate was generally observed. Some candidates did not get the precipitate to dissolve in excess. When the precipitate had dissolved, some candidates did not mention that a colourless solution was formed.

(b) Many candidates recorded damp red litmus turning blue. Some did not go on to identify ammonia despite the fact that they could find this from the qualitative analysis data sheet.

(c) Many candidates observed the white precipitate but some thought that it dissolved in excess.

(d) Candidates identified the two cations based on the observations that they had made.

(e) Many candidates described effervescence, some recognised that the piece of magnesium becomes smaller and the solution becomes warm. Few candidates described the formation of a colourless solution. There were a number of gases and tests suggested which was unexpected given the amount of hydrogen produced when magnesium reacts.

(f) Most candidates obtained a white precipitate.

(g) Candidates identified the cation and anion based on the observations that they had made in **(e)** and **(f)**.

Question 3

Candidates needed to consider two aspects of the planning question. Firstly, they had to produce the ammonium sulfate from the sulfuric acid and aqueous ammonia provided.

Common errors in the preparation included:

- Some candidates thought they had a solution of aqueous ammonium sulfate at the start and so did not gain credit for the preparation.
- Some candidates thought that the aqueous ammonia or sulfuric acid were solids and so could be added in excess and then filtered from the solution to make the ammonium sulfate.
- Some candidates used the titration method but did not repeat the experiment without indicator and so the ammonium sulfate would have been impure.

The second part of the plan involved making the solid crystals. Credit was awarded more often than those for the preparation, but some candidates stopped after making ammonium sulfate solution. Candidates are expected to know that evaporating a solution to dryness is generally not suitable for the formation of crystals.

CHEMISTRY

Paper 5070/32
Paper 3 Practical Test

Key messages

- Successful candidates carefully carried out the practical techniques required, recorded their data accurately and fully described their observations. They made full use of the 'Notes for use in qualitative analysis' sheet that is provided to conclude the identifications of the chemicals provided.

- Better performing candidates were familiar with the method for the preparation of a pure, soluble salt and described it comprehensively.

General comments

Candidates were very good at observing obvious results, such as effervescence; a precipitate forming or a precipitate dissolving. Sometimes the less visually obvious changes, such as a colourless solution being formed, were omitted. This was relevant in **Questions 2(a)** and **2(b)**. Candidates need to read carefully the information provided, both in the question and in the 'Notes for use in qualitative analysis' sheet. Care in reading the question was particularly relevant in **Questions 1(b)** and **3**. The 'Notes for use in qualitative analysis' sheet should have been used in **Question 2**.

Question 1

(a) Candidates were asked to conduct experiments by mixing various volumes of **Q** with **P**. They should have measured the initial and final temperatures and calculated the temperature rise. Many candidates successfully completed these tasks and obtained results very similar to the Supervisor's results. The most common error was not writing initial and final temperatures to the nearest 0.5 °C.

(b) Candidates were asked to draw a graph of temperature rise against volume of **Q** (from Table 1.1) onto the grid given. This was very well answered. The instructions on how to draw the lines of best fit were given in the question stem. Most candidates followed these instructions correctly. However, there were some candidates who did not follow the instructions and drew incorrect lines of best fit. If candidates had taken time to carefully read the question before starting their graph it would have helped some to avoid errors.

(c) Candidates had to read the value of the intersection from their graph. Most candidates that had correctly drawn the intersection from **(b)** were successful in giving the correct value for this answer. For those that were unsuccessful, this was usually to do with misunderstanding the scale on the axis.

(d) For this question, candidates were asked to use their value from **(c)** to calculate the concentration of sulfuric acid in **Q**. The best responses had clearly laid out their answers. They successfully calculated the number of moles of sodium hydroxide, then used that answer and their value from the intersection to calculate the concentration of sulfuric acid. Some candidates successfully calculated the number of moles of sodium hydroxide and then were not sure how to use that value in the calculation of concentration. Candidates should make all attempts to lay out their working clearly. Some candidates missed the opportunity for an error carried forward by just giving lots of unidentified numbers in the answer space.

(e) Most candidates correctly recognised that there would be more energy transferred to the surroundings as metal is a good conductor of heat. The candidates should have then realised that this would make the gradient less steep. Most candidates incorrectly stated that the gradient would be steeper.

(f) The vast majority of candidates realised that a burette would be more precise (or accurate) than a measuring cylinder.

Question 2

(a) Candidates were instructed to place a sample of solid **Y** (zinc carbonate) in a boiling tube and add nitric acid. Most candidates correctly gave the observation that there was effervescence (fizzing/bubbles). Most candidates did not also realise that observations regarding the solid (that the solid disappeared leaving a colourless solution) were required. Many candidates tested the gas produced by bubbling through limewater and correctly determined that as the limewater turned milky, carbon dioxide gas had been produced.

(b) Candidates should have observed that on addition of a few drops of aqueous sodium hydroxide, a white precipitate was formed. On addition of more aqueous sodium hydroxide, the precipitate dissolved, leaving a colourless solution. While many candidates did observe this, the colourless solution was not always mentioned as an observation.

(c) Candidates should have observed that on addition of a few drops of aqueous ammonia, a white precipitate was formed. On addition of more aqueous ammonia, the precipitate dissolved. Candidates generally obtained the correct observations.

(d) Candidates were asked to identify the cation and anion in **Y** based on the tests that they carried out in **(a)**, **(b)** and **(c)**.

(e) Candidates were instructed to complete a test on solution **Z** that caused a gas to be produced. They were then asked to test the gas produced and give the result obtained. They were instructed to add sodium hydroxide and gently warm the mixture. From looking at the 'Notes for use in qualitative analysis' sheet they should have realised that the only test described that involves the addition of sodium hydroxide and warming (without adding aluminium foil) is the test for the ammonium cation. This (along with the smell of the gas) should have directed them to the conclusion that ammonia gas was produced which they should then have tested with damp red litmus paper. The test is described on the 'Notes for use in qualitative analysis' sheet.

(f) Many candidates correctly carried out the addition of nitric acid and aqueous silver nitrate to the mixture from **(e)** and obtained a white precipitate.

(g) Using their results from **(e)** and **(f)** many candidates successfully realised that **Z** was ammonium chloride.

Question 3

The question asked candidates to plan an experiment to prepare pure dry crystals of copper(II) sulfate using common laboratory apparatus, dilute sulfuric acid and solid copper(II) oxide. There were many candidates who gave excellent, comprehensive answers. The question adds context by referring to a use of copper(II) sulfate on plant leaves. Some candidates then described preparation of a salt by using plant leaves, when the question clearly states which chemicals they are to use. Careful reading of the question is required here. Close attention to the question would also inform candidates that they were to include apparatus needed. While most candidates did this, some missed out the names of equipment.

The majority of candidates described adding the copper(II) oxide and sulfuric acid. However, some omitted any stirring, mixing, or warming of the mixture. Only a minority of candidates recognised that the copper(II) oxide should be added in excess. Another common omission was the filtration of the mixture (to filter out excess copper(II) oxide). A number of candidates simply added the copper(II) oxide to the sulfuric acid and then described heating until saturation. A number of candidates described heating the mixture until all of the water has evaporated. They therefore described heating to dryness and did not achieve credit for heating until saturation. Most candidates correctly described leaving the mixture to cool for crystals to form. While many candidates completed their answers by describing how to dry the crystals, others missed out this last point. If the candidates had carefully checked the question against their answer, they may have realised that as they were asked to prepare ‘pure, dry’ crystals, they should have included some description of the drying process.

A number of candidates either omitted this question entirely or gave very minimal answers. Some direction in exam technique may be required for those candidates. Candidates should be aware of the time that is available to them and use their time accordingly. By missing out the last question entirely they are missing out the highest scoring question of the paper (aside from the data gathering **Question 1(a)**).

CHEMISTRY

Paper 5070/41
Paper 4 Alternative to Practical

Key messages

- Credit was often not awarded because candidates did not read the questions carefully enough and so wrote answers that did not relate to the questions set and the answers required.

General comments

Candidates need to improve their skills in drawing chemical apparatus.

Candidates need to make better use of the 'Notes for use in qualitative analysis' data sheet provided.

Comments on specific questions

Question 1

(a) Most candidates were able to identify a conical flask.

(b) Candidates found it difficult to draw clear diagrams. When diagrams are drawn, they should always be labelled. Many candidates were able to show the delivery tube leaving the conical flask above the level of the liquid but best practice would show the tube with a clear gap between the liquid and the tube, not just a couple of millimetres. Candidates who were able to draw a collection vessel for the gas mainly chose to try to draw a gas syringe. This should be clearly attached to the delivery tube so that gas cannot leak. The syringe should show volume graduations on it.

(c) The most common error was to calculate the rate in cm^3 per minute instead of per second.

Question 2

(a) Many candidates were able to determine the values to insert in the table. As well as correctly determining the values, candidates were also expected to look at the precision shown in the table and to express their answers to the appropriate number of decimal places. Some candidates wrote 15.0 instead of 15 and others 18 instead of 18.0.

(b) This question tested candidates' ability to read values from equipment. Some candidates found this difficult. They were expected to place a mark on the thermometer at the appropriate temperatures. Since this is a thermometer, rather than a burette, drawing a meniscus was not essential.

(c) Most candidates were able to plot the points correctly but many found it difficult to understand the concept of needing to draw two straight lines of best fit. The difficulty of the question was eased slightly by the instruction to draw a line of best fit for the first four points and a separate line for the last three points. Despite this, a number of candidates drew a single curve for all of the points and others drew a third line connecting the fourth point to the fifth point rather than extending the lines to a point of intersection.

(d) Where a point of intersection had been drawn candidates generally read the value from the graph correctly.

(e) The most common error in this calculation was to use a value of $25\,cm^3$ instead of the value from **(d)**.

(f) Many candidates were familiar with the idea of the precision of a piece of measuring equipment in relation to the number of decimal places to which the scale can be read.

(g) Many candidates knew that plastic is a better insulator, but fewer candidates went on to explain that this means there is less energy transferred to the surroundings in the experiment.

(h) Many candidates recognised that stirring distributes the heat evenly but a number referred to the mixing of the chemicals instead.

Question 3

(a) (i) A number of candidates did not notice that this part of the question referred to the method and they described an observation instead. They needed to recognise that excess sodium hydroxide is needed for the precipitate to dissolve.

(ii) Many candidates simply repeated the observation given in the table rather the describing the solution formed when the precipitate dissolves as colourless.

(iii) Many candidates were unable to recognise that litmus must be red for the test to work and therefore, to suggest that blue litmus had been used instead.

(iv) Many different ions were suggested.

(v) Few candidates were able to recognise that more than one ion gives the same observation and hence to suggest aluminium and zinc ions. If candidates choose to use the formulas of ions to identify them then they must be completely correct in terms of symbol and charge.

(vi) A number of candidates suggested a cation rather than an anion.

(b) (i) Few candidates knew that the ion which turns universal indicator red is a hydrogen ion. Common incorrect answers were 'acid' or a named acid such as hydrochloric acid rather than a cation.

(ii) Many candidates described effervescence. Some recognised that the piece of magnesium becomes smaller and the solution becomes warm. Few candidates described the formation of a colourless solution.

(iii) Most candidates were able to describe the test for hydrogen. This was a straightforward question given that all the gas tests are given on the 'Notes for use in qualitative analysis' provided.

(c)(i) Appropriate use of the 'Notes for use in qualitative analysis' should have made this question straightforward. However, a number of candidates did not get it correct.

(ii) This question required candidates to correctly combine their answer from **(b)(i)** with their answer form **(c)(i)**.

Question 4

Candidates needed to consider two aspects of the planning question. Firstly, they had to produce the ammonium sulfate from the sulfuric acid and aqueous ammonia provided.

Common errors in the preparation included:
- Some candidates thought they had a solution of aqueous ammonium sulfate at the start and so did not gain credit for the preparation.
- Some candidates thought the aqueous ammonia or sulfuric acid were solids and so could be added in excess and then filtered from the solution in order to make the ammonium sulfate.
- Some candidates used the titration method but did not repeat the experiment without indicator and so the ammonium sulfate would have been impure.

The second part of the plan involved making the solid crystals. Credit was awarded more often than for the preparation but some candidates stopped after making ammonium sulfate solution. Candidates are expected to know that evaporating a solution to dryness is generally not suitable for the formation of crystals.

CHEMISTRY

Paper 5070/42
Paper 4 Alternative to Practical

Key messages

- Successful candidates carefully read the information given in questions and used that to consider their answers. They made full use of the 'Notes for use in qualitative analysis' sheet that is provided and ensured that they wrote enough points in their answers to fulfil the number of marks available.
- Better performing candidates were familiar with the method for the preparation of a pure, soluble salt and described it comprehensively.

General comments

The main difficulties for candidates arose when candidates did not take time to carefully read questions; did not answer in clear, sufficient detail or did not use the 'Notes for use in qualitative analysis' sheet. Examples of questions which seemed to be affected by lack of care in reading the information given prior to answering are **Questions 2(a)**, **2(c)**, **2(h)**, **3(b)(i)** and **4**. The questions where some candidates did not answer in sufficient detail or clearly enough are **Questions 2(e)**, **3(a)(iii)**, **3(a)(v)**, **3(b)(i)** and **3(b)(ii)**. The 'Notes for use in quantitative analysis' sheet could have been used in most of **Question 3**.

Question 1

(a) Most candidates were successful in identifying the piece of equipment as a test-tube.

(b) The majority of candidates realised that iron electrodes are not used during the electrolysis because they are not inert and would react.

(c) Some candidates successfully recognised that chlorine gas is toxic, or harmful. Candidates did not seem to link the production of a toxic gas with the need for ventilation, or the need to use a fume cupboard. Many candidates referred to the use of masks, gloves or goggles, instead of recognising that the danger is in breathing in the gas, so a fume cupboard is needed.

(d) A majority realised that the gas produced at the cathode was hydrogen and most gave the correct test for the gas.

Question 2

(a) Candidates were asked to complete the three missing values in a results table for when sulfuric acid is neutralised by aqueous sodium hydroxide. This was generally well answered. The main error was in not following the pattern of decimal places as shown by the existing results in the table, for example writing 15 rather than 15.0 or writing 0.0 rather than 0. Candidates should be encouraged to spend time looking at the existing formatting of the table to inform them of how to write their answers correctly. Correct answers were 2.5, 15.0 and 0.

(b) Candidates were asked to complete the missing liquid levels inside two thermometers. The majority of candidates answered this question successfully.

(c) Candidates were asked to draw a graph of temperature rise against volume of **Q** (from Table 2.1) onto the grid given. This was very well answered. Some candidates plotted the point at (18.0, 8.0) incorrectly and should be reminded to double check the values given, rather than assuming that they will follow a regular pattern. The instructions on how to draw the lines of best fit were given in the question stem. Most candidates followed these instructions correctly. There were some candidates who did not follow the instructions and drew incorrect lines of best. It is another instance when taking time to carefully read the question before starting the answer would be beneficial to the candidates.

(d) Candidates had to read the value of the intersection from their graph. Most candidates that had correctly drawn the intersection from **(c)** were successful in giving the correct value for this answer.

(e) For this question, candidates were asked to use their value from **(d)** to calculate the concentration of sulfuric acid in **Q**. The best responses had clearly laid out answers. They successfully calculated the number of moles of sodium hydroxide, then used that answer and their value from the intersection to calculate the concentration of sulfuric acid. Some candidates successfully calculated the number of moles of sodium hydroxide and then were not sure how to use that value in the calculation of concentration. Candidates should make all attempts to lay out their working clearly. Many candidates missed the opportunity for an error carried forward mark by just giving lots of unidentified numbers in the answer space.

(f) Most candidates correctly recognised that there would be more energy transferred to the surroundings as metal is a good conductor of heat. The candidates should have then realised that this would make the gradient less steep. Most candidates incorrectly stated that the gradient would be steeper.

(g) The vast majority of candidates realised that a burette would be more precise (or accurate) than a measuring cylinder.

(h) This question asked the candidate to state the dependent variable. Most of the candidates did not seem to understand the term ‘dependent variable’. The most common incorrect answers were volume of **P** or temperature (alone). When looking at the results table given in Table 2.1, candidates should have appreciated that there were 3 columns that involved ‘temperature’. Answering just ‘temperature’ would not be correct as it could be referring to any one of those columns. The correct answer was ‘temperature rise’, indicating that the candidate was aware that it was the change in the temperature shown in the final column of the table that was the dependent variable.

Question 3

Candidates should be reminded that they are provided with ‘Notes of use in qualitative analysis’ sheets at the back of the question booklet and that they should be sure to make use of this in the examination.

(a) (i) Candidates were asked to identify the gas produced in the reaction of solid **Y** and sulfuric acid. The question stem clearly tells the candidates that solid **Y** is a carbonate. Whilst most candidates correctly stated that carbon dioxide gas would be produced, a significant number gave the name of a different gas.

(ii) This question asked for a reagent that would form a white precipitate when reacted with the anion produced in test 1. In test 1, sulfuric acid is used. The candidates should therefore have recognised that they were being asked to identify the reagent used in a sulfate test. They could then have looked up the correct test in the ‘Notes for use in qualitative analysis’ sheet, reading that the reactant needed was barium nitrate. A lot of the candidates gave the answer of silver nitrate, by either misidentifying the test that they needed to look up, or by using the notes sheet incorrectly.

(iii) A majority gave the correct response of a colourless solution being formed. Some candidates stated ‘colourless’ alone and should be reminded that they need to be specific in their answer.

(iv) Most candidates correctly determined that the two cations that could be present were aluminium and zinc. This was another question where candidates should have made use of the ‘Notes for use in quantitative analysis’.

(v) Candidates were asked to describe an additional test to identify the cation in **Y**. Many candidates gave the correct description of adding excess aqueous ammonia. A number of candidates correctly realised that aqueous ammonia should be added but did not mention ‘excess’. This is the type of question where candidates should be encouraged to double check their answer, making sure that they are giving enough detail for the marks available.

(b) (i) There were some good answers where candidates knew that ammonia was produced and described the test for it. There were a number of candidates who did not read the question carefully enough and missed the part where it explained that the cation contains two non-metals. They then went on to describe unrelated tests. For those that did correctly realise that they were testing for ammonia, the candidates needed to ensure that they gave the full test in order to get the full credit. There were a number of candidates who contradicted themselves by adding other reactants, such as aluminium. Careful checking of the answer by the candidates is to be encouraged to ensure they are not describing other tests that are not required.

(ii) Candidates should have recognised that by testing the separate solutions of chloride and bromide with nitric acid and silver nitrate they could then obtain precipitates with which to compare the unknown precipitate and identify it. Many candidates did not realise what was required by the question at all. For those that did understand the question, a fair number then were not clear enough with their answer. For example, they referred to comparing the chloride and bromide precipitates with each other, rather than with the precipitate obtained from **Z**.

(iii) Candidates were expected to recognise that the sulfate ion test described would be negative, so the observation would be ‘no change’ or ‘colourless solution’. Most candidates instead gave the answer ‘white precipitate’.

Question 4

The question asked candidates to plan an experiment to prepare pure dry crystals of copper(II) sulfate using common laboratory apparatus, dilute sulfuric acid and solid copper(II) oxide. There were many candidates who gave excellent, comprehensive answers. The question adds context by referring to a use of copper(II) sulfate on plant leaves. Some candidates then described preparation of a salt by using plant leaves, when the question clearly states which chemicals they are to use. Careful reading of the question is required here. Close attention to the question would also inform candidates that they were to include apparatus needed. While most candidates did this, some missed out the names of equipment.

The majority of candidates described adding the copper(II) oxide and sulfuric acid. However, some omitted any stirring, mixing, or warming of the mixture. Only a minority of candidates recognised that the copper(II) oxide should be added in excess. Another common omission was the filtration of the mixture (to filter out excess copper(II) oxide). A number of candidates simply added the copper(II) oxide to the sulfuric acid and then described heating until saturation. A number of candidates described heating the mixture until all of the water has evaporated. They therefore described heating to dryness and did not achieve credit for heating until saturation. Most candidates correctly described leaving the mixture to cool for crystals to form. While many candidates completed their answers by describing how to dry the crystals, others missed out this last point. If the candidates had carefully checked the question against their answer, they may have realised that as they were asked to prepare ‘pure, dry’ crystals, they should have included some description of the drying process.