# CHEMISTRY

**Paper 5070/11**
**Multiple Choice**

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

## General Comments

All the questions discriminated well between the candidates and the paper was a good test of the candidates' ability.

## Comments on Specific Questions

### Question 5

Aluminium hydroxide and zinc hydroxide are amphoteric and both dissolve in excess sodium hydroxide. All ammonium compounds are soluble and therefore option **B**, $Ca^{2+}$, was the answer. Calcium hydroxide, a base, is insoluble in excess sodium hydroxide.

### Question 6

Options **B**, **C** and **D** were almost equally popular answers. The question tested the knowledge that carbon always forms four covalent bonds, hydrogen one, oxygen two and nitrogen three.

**Question 12**

The responses to this question were split between options **B** and **C** with **B** being correct. Knowing the empirical formula of a compound it is possible to deduce its molecular formula from a knowledge of its relative molecular mass.

**Question 13**

During the electrolysis of any ionic salt the metal ions are always discharged at the negative electrode forming atoms of the metal.

**Question 24**

All the alternatives were popular for what was essentially a recall question.

**Question 27**

Calcium was the only metal in the question above aluminium in the reactivity series. Aluminium is manufactured by electrolysis and it could be deduced that any metal more reactive than aluminium would also be extracted from its ore by electrolysis.

**Question 34**

The uses of kerosene and gasoline were frequently confused.

**Question 39**

Oxygen was the only substance which did not carry out an addition reaction with ethene. Carbon dioxide and water are the two products of the reaction between ethene and oxygen.

# CHEMISTRY

**Paper 5070/12**
**Multiple Choice**

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

## General Comments

Candidates performed well on this paper.

## Comments on Specific Questions

### Question 5

Graphite and magnesium both have a 'sea of electrons' and conduct electricity. Only magnesium has a lattice of positive ions.

### Question 8

The knowledge that carbon always forms four covalent bonds, hydrogen one, oxygen two and nitrogen three was being tested in this question.

**Question 9**

Many candidates did not read the question carefully and incorrectly selected **A** as the answer.

**Question 11**

The answers to this question were split between options **B** and **C**, with **B** being correct. Knowing the empirical formula of a compound it is possible to deduce its molecular formula from its relative molecular mass.

**Question 18**

Substances with giant molecular structures have high melting points and boiling points. Carbon dioxide is a gas and consists of simple covalent molecules and does not have a giant molecular structure.

**Question 23**

Zinc displaces copper from a solution of copper(II) sulfate and the zinc goes into solution as zinc ions. Zinc atoms each lose two electrons when they form ions and this is oxidation. Therefore option **C** was the correct answer.

**Question 33**

The use of kerosene and the use of gasoline were frequently confused.

# CHEMISTRY

**Paper 5070/21**
**Theory**

## Key messages

- Answers to quantitative questions should include clear working out.
- It is better to attempt an answer than to leave the space blank as credit cannot be awarded for a blank space.
- Candidates should be advised to read the questions carefully before starting their answer.

## General comments

Most candidates followed the rubric of the question paper and attempted just three questions from **Section B**. A small proportion of candidates attempted all four questions from **Section B** and then crossed out their answers to one of these questions.

A significant proportion of the candidates left many questions blank even when it was an objective question.

Candidates often found the short answer questions less challenging than those which required extended answers. Good answers used the correct chemical terms and/or illustrated answers with clear labelled diagrams. Some candidates gave imprecise and vague extended answers; these candidates could be advised to use bullet points rather than writing in paragraphs.

Good answers to quantitative questions included clear working out so that credit could be awarded for error carried forward.

## Comments on specific questions

### Section A

### Question A1

A significant proportion of candidates did not attempt some of the questions and left them blank. Centres should advise candidates to attempt all questions like this because there is no penalty for writing the incorrect answer.

**(a)** Many candidates correctly gave $V_2O_5$ as the catalyst used in the Contact process but others gave $MnO_2$.

**(b)** A significant proportion of the candidates recognised $ZnSO_4$ but others gave $(NH_4)_2SO_4$ instead.

**(c)** Candidates did not often recognise AgI as the insoluble salt and many other salts were given as incorrect answers.

**(d)** The CFC $C_2F_3Cl_3$ was the most frequent answer given but many candidates had the misconception that $CH_4$ was involved in ozone depletion.

**(e)** Often candidates correctly chose one of the sulfates $ZnSO_4$ or $(NH_4)_2SO_4$ but other candidates gave KI and $K_2Cr_2O_7$.

**(f)** Although many candidates correctly chose $CH_4$ others chose the alkene $C_3H_6$ instead.

**(g)** Many candidates recognised $(NH_4)_2SO_4$ as a fertiliser.

**Question A2**

Many candidates found this question about copper and some of its compounds very demanding and often several part questions were left blank. In each case the correct formula was accepted instead of the name of the compound.

**(a)** Only a small proportion of candidates identified the gas **Z** as sulfur dioxide. Candidates often gave hydrogen or carbon dioxide as possible gases.

**(b)** Many candidates were able to identify the blue solution as copper(II) sulfate, although the mark scheme also accepted copper sulfate.

**(c)** Only an extremely small proportion of the candidates were able to write the correct ionic equation. Many candidates gave equations that did include ions and involved copper containing compounds.

**(d)**

**(i)** Most candidates were unable to identify copper(II) hydroxide and often left the question blank. Incorrect answers included copper oxide, copper and copper sulfate.

**(ii)** Only a very small proportion of the candidates were able to write the equation to make copper(II) hydroxide from copper(II) ions and hydroxide ions. Most of these candidates were able to include the correct state symbols.

**(e)** Only a small proportion of the candidates could calculate that the empirical formula was CuO. Common misconceptions included using the atomic numbers rather than the relative atomic masses when calculating the molar ratios or using 32 instead of 16 for the relative atomic mass of oxygen. A number of candidates inverted the expression for moles and took the relative atomic masses and divided these by the percentages.

**Question A3**

**(a)**

**(i)** Many candidates recognised that the isotopes had the same number of protons, however candidates that referred to the same atomic number were not given credit since the question referred to sub-atomic particles. The same number of electrons was also accepted on the mark scheme but only a very small number of candidates gave this answer. Only a small proportion of candidates incorrectly referred to neutrons.

**(ii)** Many candidates recognised that the isotopes had a different number of neutrons however candidates that referred to the same mass number were not given credit since the question referred to sub-atomic particles. Only a small proportion of candidates incorrectly referred to protons.

**(b)**

**(i)** Most candidates could not construct the equation and often used the incorrect formulae even when they were given in the stem. A common misconception was to have $HF_2$ as the formula for hydrogen fluoride.

**(ii)** Most candidates could not construct the equation and often used the incorrect formulae. Common misconceptions included using $Mg_2$ for magnesium and magnesium fluoride as MgF or $MgF_4$.

**(iii)** Some candidates gave excellent answers and explained reduction in terms of loss of oxygen, gain of hydrogen, gain of electrons and a reduction in the oxidation state. Only one of these answers was needed to be awarded credit for this question and unfortunately some candidates gave contradictory statements when they gave more than one definition.

**(iv)** Candidates got full credit for the answer 0.881 tonnes but the use of tonnes confused some candidates who made mistakes converting tonnes into grams. Candidates used a variety of methods to solve the question including using percentage composition, mole or mass ratios.

A common misconception was to work out how much uranium from uranium(IV) fluoride rather than uranium(IV) oxide.

**(c)** Although a significant proportion of the candidates placed uranium between copper and magnesium, other candidates had uranium being extremely unreactive or extremely reactive.

**Question A4**

**(a)** Only a very small proportion of candidates could draw the 'dot-and-cross' diagram for hydrogen peroxide. Many candidates did not know the order of the atoms in hydrogen peroxide and gave a diagram having hydrogen - hydrogen bonds or even cyclic structures.

**(b)** Candidates often gave the differences between solids and liquids rather than between liquids and gases. Candidates only had to state that particles of a gas move faster and a further apart from one another than particles of a liquid. Often candidates referred to random motion or how free the particles were but very seldom made a comparative statement.

**(c)** Most candidates could not use collision theory to explain why pure hydrogen peroxide reacts faster than dilute hydrogen peroxide. Candidates needed to refer to the hydrogen peroxide molecules being closer together and hence having more collisions per second in pure hydrogen peroxide. A common misconception was that the molecules in pure hydrogen peroxide have more energy.

**(d)**

**(i)** The mark scheme only required $Fe^{2+} \rightarrow Fe^{3+} + e^-$ but many candidates tried to construct equations involving hydrogen peroxide.

**(ii)** Good answers used aqueous sodium hydroxide forming a red-brown precipitate. Some candidates used oxidising agents such as potassium manganate(VII) or potassium dichromate(VI) to test for the presence of $Fe^{2+}$ ions.

**(e)** The mark scheme only required candidates to recognise that hydrogen peroxide was both an oxidising agent and a reducing agent. A small proportion of candidates were able to make these deductions but often candidates only gave one of the deductions.

**Question A5**

**(a)** Most candidates could recall the percentage by volume of nitrogen in clean, dry air.

**(b)** Some candidates were able to give a detailed explanation and included more details than were needed such as the removal of water and carbon dioxide before the air is liquefied. Other candidates just gave the straight forward answer, fractional distillation of liquid air, and made no attempt to explain how the method worked. A small proportion of the candidates misunderstood the question and described how plants and animals extracted oxygen from the air.

**(c)** Most candidates gave a very poor explanation for why the composition of air remains constant. The candidates often named the processes photosynthesis, respiration and decomposition but did not explain what happened in these processes. Very few candidates mentioned combustion. The mark scheme required why both the percentage of carbon dioxide and oxygen remained constant but most candidates focused on carbon dioxide. A common misconception was to refer to just carbon rather than carbon dioxide.

**(d)** Most candidates could not recall the use of calcium carbonate in terms of reducing the effects of burning fossil fuels. A common misconception was that calcium carbonate was added to the fuel before it was burned rather than the gases produced being treated with the calcium carbonate to remove sulfur dioxide.

**Section B**

**Question B6**

**(a)** Some candidates appreciated that aqueous calcium nitrate contained moving ions and pentane had no free electrons. Other candidates left this part question blank.

**(b)** Many candidates were able to give the correct products of sodium and chlorine. A common misconception was to state the ions present rather than the products formed.

**(c)** Candidates found this part question more difficult than **(b)** and often included oxygen as one of the products. A common misconception was to state the ions present rather than the products formed.

**(d)** The mark scheme only required the name of the electrolyte and the nature of the electrodes. Candidates had to identify alumina or aluminium oxide as the electrolyte and bauxite was not given credit. Some candidates gave more detail explaining how bauxite was purified.

**(e)**

**(i)** Many candidates realised that electrolysis is used to purify copper. They were often able to identify the anode as impure copper but did not state that the cathode was pure copper. If an electrolyte was quoted it was most likely to be aqueous copper(II) sulfate. A small proportion of the candidates misinterpreted the question and gave a description of how copper was extracted instead.

**(ii)** Some candidates got the correct answer of 1.21 g.

**(iii)** Some candidates got the correct answer of 1.75 g.

**Question B7**

**(a)** Many candidates were able to state propanol. Either propan-1-ol or propan-2-ol were accepted in the mark scheme.

**(b)** A significant proportion of the candidates were able to draw the structure of $C_4H_{10}O$ however some of the candidates got the order of the hydrogen and oxygen incorrect having a hydrogen atom making two bonds rather than one bond. Many of the candidates realised that saturated compounds do not have double bonds present in their structure.

**(c)** Candidates were often able to deduce the formula as $C_7H_{16}O$ or $C_7H_{15}OH$. A small proportion of candidates made errors in the number of hydrogen atoms.

**(d)**

**(i)** Most candidates could not draw the structure of ethyl ethanoate.

**(ii)** Many candidates were able to suggest a use for ethyl ethanoate. The mark scheme allowed any use associated with an ester. The most popular answers were as flavours or as a perfume.

**(e)** Many candidates could not recall the equation for fermentation but did recall the use of yeast and the need for the absence of water. Only a very small proportion of the candidates mentioned the use of fractional distillation to obtain the ethanol from the reaction mixture.

**(f)** Candidates found it difficult to identify the gas produced. Often the question was left blank.

**Question B8**

.

**(a)**

**(i)** Candidates found this part question very difficult and rarely appreciated the significance of the enthalpy change in answering the question. A common misconception was to refer to the pressure rather than the temperature.

**(ii)** Many candidates appreciated that the increase in temperature will increase the rate of reaction but other candidates had the misconception that this increase in temperature would move the position of equilibrium to the right.

**(b)** Candidates often gave the enthalpy change a double headed arrow and this was not given credit. The candidates were more likely to be awarded credit for activation energy than for enthalpy change. Some candidates labelled the maximum of the curve as the activation energy while others had the product line above that of the reactant

**(c)** The explanation that a catalyst lowers the activation energy was well known by candidates.

**(d)** Only a small proportion of candidates got the correct percentage yield of 98%. A significant proportion of the candidates thought that the maximum yield was 30 moles rather than 10 moles.

**(e)** Some candidates were able to deduce the formula as $CH_3COONH_4$, but a significant number of candidates had one more or one less hydrogen atom in the formula.

**Question B9**

**(a)** Candidates were often able to describe a weak acid as one that does not fully dissociate.

**(b)** Although many candidates appreciated the use of universal indicator, many did not then state that the colour obtained can be checked against a chart to get the pH value. Other candidates used indicators such as litmus which do not have many different colours and so are not appropriate to determine the pH of a solution.

**(c)** Many candidates did not fully understand what they had to do with this question and as a result they did not calculate the moles of sulfamic acid used (0.00107) and the moles of potassium hydroxide used (0.00108) and so deduce that 1 mole of sulfamic acid reacts with one mole of potassium hydroxide. Candidates often worked out one of these amounts in moles and then assumed that the other amount must be the same basically assuming the 1:1 mole ratio they were supposed to deduce.

**(d)**

**(i)** A significant proportion of candidates were able to construct the equation although some gave hydrogen as H rather than $H_2$.

**(ii)** Very few candidates could construct this equation although a greater proportion of candidates appreciated that carbon dioxide was produced. A common error was to get the formula for calcium sulfamate incorrect.

**(e)** Some candidates identified nitrogen as the gas produced but other answers given included hydrogen, carbon dioxide, oxides of nitrogen and even oxygen.

# CHEMISTRY

**Paper 5070/22**

**Theory**

## Key Messages

- Questions requiring simple answers to inorganic chemistry were done well, while answers to physical properties and practical procedures need to contain more focused explanations.
- Questions on atomic structure and organic chemistry were generally well done, while some candidates need more practice in answering questions where unfamiliar compounds are involved.
- Calculations, especially in **Section B**, were generally done well. Other candidates need to focus on when to use explanations in terms of equilibrium and explanations in terms of rates of reaction.

## General comments

Many candidates tackled this paper well especially in **Section A**. Aspects of inorganic chemistry were generally well answered but as in previous years, questions involving physical properties and practical aspects of chemistry e.g. **Question A6**, posed challenges for some candidates. Good answers were seen in **Questions A2, A4** and **A5**. In general **Section B** questions were as well answered than those in **Section A**, the question on copper, **B9**, proving the most demanding of these.

Candidates could have gained further credit on questions which required a degree of explanation. The rubric was well interpreted and the standard of written work was generally good. The majority of candidates attempted all parts of each question in **Section A**. In both sections many candidates gave answers of the appropriate length to questions involving free response e.g. **Questions A5(a)** and **A6(b)**. The standard of English was generally good.

In **Section B Questions B8** and **B9** were the least popular. Some candidates disadvantaged themselves by writing too many points to questions requiring a specific number of answers. For example in **Question B10(c)(i)**, where two responses were required, some candidates wrote 'extra points' which were incorrect. Candidates should be advised that the inclusion an 'extra' incorrect point may result in full credit not being awarded.

Most candidates' knowledge of structure and properties in terms of atoms, ions and electrons was fairly good. Many candidates were able to explain electrical conduction in metals and 'blue diamonds'. Fewer gave successful explanations of the reasons for the high melting point of diamond. Many candidates found the question on chromatography (**Question A6**) challenging. There were a few good descriptions of how chromatography is carried out. Fewer candidates gained credit for explaining how the amino acids were identified. Many candidates muddled ideas of equilibrium with rates of reaction in **Question B7(d)**.

Some candidates were well able to construct balanced equations. Others need more practice, especially where unfamiliar compounds are involved. Many candidates performed well in questions involving calculations. Many showed appropriate working and clear indications about what each number referred to. In order to gain credit, candidates should make it clear why they are performing certain steps, rather than writing a mass of figures. For examples, please refer to the mark scheme for **Questions B7(c), B8(c)(i)** and **B10(c)(ii)**. Many relatively low scoring candidates were able to gain full credit for some of the calculations.

**Comments on specific questions**

**Section A**

**Question A1**

Part **(a)** which required candidates to identify a white solid forming an alkaline solution in water, was the least well answered of the four questions.

**(a)** Some candidates correctly identified sodium hydroxide as a white solid forming an alkaline solution in water. Most candidates suggested sodium chloride, perhaps through not focusing on the words alkaline solution.

**(b)** This was usually correct. The commonest error was to suggest copper chloride.

**(c)** Most candidates correctly identified ammonia. The commonest error was to suggest sulfur dioxide.

**(d)** Zinc carbonate was correctly chosen by many candidates. The commonest error was to suggest copper carbonate. A smaller number of candidates focused on the colour rather than the carbonate and chose copper nitrate. A few listed several answers to this part.

**Question A2**

Parts **(b)** and **(c)(ii)** proved most difficult. In **(b)** many candidates wrote the same molecule twice.

**(a)** The general formula of alkanes was well known. The commonest errors were to write the general formula for an alkene or to write $C_nH_{2n+1}$.

**(b)** About half the candidates were able to draw accurate structural or displayed formulae for the isomers of butane. The commonest error was to suggest that a bent carbon chain (either U-shaped or zigzag) was an isomer of a straight chain. In addition, drawing a straight chain of carbon atoms, some candidates drew three carbon atoms with the fourth coming off in a vertical direction in the 1-position. A considerable proportion of the candidates drew 2-methyl propane and then just rotated the structure to draw their second 'isomer'. Other errors were to draw cyclobutane, to miss off hydrogen atoms and to draw hydrogen atoms between carbon atoms..

**(c)**

**(i)** Many candidates recognised that the reaction was a substitution reaction. 'Addition' was the commonest error but elimination, exothermic and endothermic were also seen as answers.

**(ii)** About half the candidates gained credit for drawing the correct structure for a chlorine-substituted butane. Common errors were to base the structure on propane rather than butane, to write H – C*l* and to draw a particle diagram showing circles instead of a formula.

**(d)** Most candidates recognised fractional distillation. The commonest error was to suggest cracking. A minority of candidates gave both fractional distillation and cracking, so could not be awarded credit.

**Question A3**

This question was reasonably well done by many candidates. The most challenging part proved to be **(a)(i)** where many candidates wrote about polymers, monomers or polymerisation. Many recognised the bromine test for unsaturated compounds but confused their answers by referring to alkenes and alkanes, indicating that they were not sure whether it was saturated or unsaturated compounds which have C=C double bonds. The calculation in **(d)** was generally well done.

**(a)**

**(i)** The best answers were given by candidates who recognised the two parts of the word poly- and unsaturated and stated the meaning of both. A number of candidates wrote about monomers reacting to form polymers and suggested that the polymers then had unsaturated bonds. A large minority of candidates wrote about ethane and ethene or alkanes and alkenes rather than using the words saturated and unsaturated. Where candidates did recognise that double bonds were involved, they sometimes did not mention that carbon atoms were involved. A small number of candidates also suggested that one or more double bonds were present, rather than more than one.

**(ii)** This question was generally well answered with most candidates giving the correct test. Most mentioned both the result with the saturated and unsaturated oil. Common errors included mention of differences in density or hardness and using sodium hydroxide.

**(b)** Most candidates correctly identified hydrogenation or reaction with hydrogen. Some candidates correctly identified nickel as the catalyst but did not write about hydrogen. A common error was to suggest hydration.

**(c)** This was generally well answered. A considerable minority of the candidates gave formulae for various hydrocarbons as well or in place of either carbon dioxide or water. Some candidates listed carbon monoxide as a product through not noting that complete combustion was stated in the stem of the question.

**(d)** The calculation was well answered by most candidates. The commonest error was to count only one nitrogen atom in the ammonium nitrate.

**(e)**

**(i)** Most candidates gained full credit. Many candidates referred to a variety of other atmospheric phenomena including destruction of ozone and acid rain. A considerable number wrote about nitrogen oxides, presumably because of the nitrate in the stem of the question. The commonest errors were to write about flooding or weather changes in a general sense rather than providing the qualifications about flooding low-lying areas (thus relating it to sea-level rises) or climate change on a larger scale.

**(ii)** A few candidates constructed a correct equation. Others did not use the formula for nitrous oxide that was given in the question and so did not identify correctly the second product (water). Some listed three products even though the question implied that there were only two. The main errors were ammonium compounds as products, writing $H_4O_2$ instead of water and incorrect transcription of the formula for $N_2O$ (usually as $NO_2$).

**Question A4**

This question was one of the best answered on the paper. Parts **(b), (c), (e)(ii)** and **(e)(iii)** were particularly well answered. In **(a)** the word valency was not particularly well understood.

**(a)** Many candidates gave the number of valency electrons of the Group VII elements correctly as 7. Others gave answers such as 1 (perhaps referring to the charge on the ion) or 117 (the number of protons). Other errors were 3 or giving an electronic structure such as 2, 8, 7.

**(b)** Most candidates deduced correctly the number of protons and neutrons.

**(c)** Many candidates gave two suitable physical properties. The commonest errors were to suggest that the melting or boiling point of the halogen would be high, to suggest that the melting point is higher – without stating what it is being compared with, suggesting that the element would be a gas, giving chemical properties e.g. reactivity or suggesting that the element is coloured, without any mention of a specific colour.

**(d)**

**(i)** A minority of candidates recognised that fluorine is diatomic and wrote the correct equation. Most candidates incorrectly wrote fluorine as F or magnesium fluoride as MgF. A significant minority of candidates wrote the formula for fluorine as F*l*.

**(ii)** Most candidates scored at least partial credit for this part, generally for the correct charge on the ions. Common errors included using the atomic structure of F and Mg, writing the fluoride ion as $F^{2-}$ or only drawing the outer electron shells. A small number of candidates wrote the electronic structure of chlorine (with C*l* in the centre as well). Very few drew a covalent structure.

**(e)**

**(i)** Some candidates drew good diagrams to show the electronic structure of the halogen compound. Others were rather careless in the way they drew the structures, often overlapping the outer electron shells so that it was difficult to see which electron belonged to which atom. The commonest error was to omit the 6 non-bonding electrons from the halogen atoms.

**(ii)** This question was well answered. The commonest errors were to suggest high melting point or that it does not conduct electricity (which is in the stem of the question).

**(iii)** Most candidates gained credit for this question, usually for the depletion of ozone. Although some candidates may muddle the various environmental effects, credit was given in this case for the answer 'global warming' since CFCs are potent greenhouse gases.

**Question A5**

This question provided many candidates with a challenge, especially **(a)** and **(b)(ii)**. Some wrote rather vague and incorrect statements about ions or intermolecular forces. Parts **(b)(i)** and **(c)** were well answered by most candidates.

**(a)** Many candidates appreciated that a high amount of energy was required to break the strong covalent bonds. Few realised that there was a network of covalent bonds or many covalent bonds present. Some candidates mentioned either intermolecular bonding, layers with weaker bonds between or van der Waals' forces.

**(b)**

**(i)** This was generally well answered. Common errors included no valence electrons, no moving ions or reference to layers moving over each other (mistaking diamond for graphite).

**(ii)** Candidates who expressed the answer in the simplest way 'mobile electrons present' usually gained credit. Others wrote too much and then contradicted themselves. A number of candidates gave the insufficient answer 'it has no valence electrons'. Some realised that it was the 'extra' carbon electron that was responsible for conduction. Many candidates simply referred to the boron atom as conducting. Common errors were to suggest that boron is a metal or boron has free electrons.

**(c)** Many candidates did well on this question. Others wrote that 'graphite is cheap' or 'the layers slide over each other' or 'it is a lubricant' none of which answers the question.

**Question A6**

Most candidates did well in **(a)** and some candidates gained full credit in **(b)**. Others need more practice with questions about practical methods such as chromatography.

**(a)** Most candidates answered this question correctly. The main errors were terylene, proteins or peptides and polyester.

**(b)** A few candidates read the stem of the question in full and gained full credit. Others did not appear to read the stem in its entirety i.e. 'how paper chromatography can be used to identify amino acids'. This resulted in many candidates only writing about the separation technique and not about $R_f$ values and how they are used. Some candidates took great care with their diagrams and labelled them fully. Others were content to draw the paper not dipping into the solvent or not labelling the solvent. The main errors were not drawing or stating that the solvent level should be below the starting line, placing a locating agent in the solvent at the start of the experiment, adding protein to the chromatography paper rather than the amino acid mixture or suggesting that hydrolysis took place on the chromatogram. Credit was least commonly awarded for comparing the running of the known amino acids with the unknown ones in the mixture or comparing $R_f$ values with known ones for the individual amino acids.

**Section B**

**Question B7**

Most candidates chose to do this question. There were some good answers to **(b)** and **(d)** and the calculation was generally well constructed.

**(a)** This was well answered. Some candidates gave ambiguous statements making the energy input sound like activation energy rather than enthalpy change. Others wrote statements about bond energies which were not always correct. Candidates should be advised to keep the answers to such questions as simple as possible e.g. a reaction where energy is absorbed.

**(b)** Some candidates drew good diagrams which were fully and carefully labelled. Others drew the arrows to show activation energy and enthalpy change inaccurately or placed $E_a$ and $\Delta H$ at inappropriate places on the diagram without arrows or bars at all. Common errors were to draw the products at a lower level than the reactants, to draw the activation energy from the product to energy maximum and the absence of an energy maximum.

**(c)** Many candidates answered this calculation question well, and provided relevant working. The main error was not to convert grams of nitrogen to moles of nitrogen. There were a number of points where candidates rounded up in the calculation. On this occasion, the Examiners took account of this. Candidates should be encouraged not to round up during a calculation as this may lead to significant errors.

**(d)** Some candidates gave good and succinct answers involving the particles being closer together at a higher pressure and this leading to a greater frequency of collisions. Others thought that the question was about equilibrium and wrote about the forward and backward reactions. Many candidates wrote incorrectly about the particles having greater energy or speed when the pressure is increased. Other common errors included reaction increases (rather than referring to rate increasing), volume decreases without referring to the proximity of particles, referring to more collisions rather than collision rate or more collisions per second and referring to more effective collisions (the effect of increasing temperature not pressure).

**Question B8**

This question was the least popular from **Section B**. The calculation was generally well done. Many candidates calculated the moles of hydrochloric acid rather than the moles of hydrogen from the graph as the basis of their calculation. Many found **(b)(ii)** and **(d)** challenging.

**(a)** Most candidates wrote the formula for a hydrogen ion correctly. The main errors were to write the word hydrogen ion rather than give the formula, $OH^-$ ions or writing the formulae of two ions.

**(b)**

**(i)** Most candidates recognised that carbon dioxide is the gas given of when propanoic acid reacts with magnesium carbonate. Some thought that hydrogen was given off.

**(ii)** Some candidates wrote clear and unambiguous formulae for magnesium propanoate. The main errors were $C_2H_5COOMg$, $C_2H_7COOMg$ $(C_2H_5COOH)_2Mg$ and $CH_3COOMg$.

**(c)**

**(i)** Where candidates read the question correctly and used the information from their graph they generally received full credit. A significant proportion of the candidates calculated the mass of magnesium by using the concentration and volume of the hydrochloric acid.

**(ii)** Most candidates recognised that the same volume of hydrogen would be produced at the end of the reaction. They also recognised that the rate would be lower and so gave a correct initial gradient. Many did not show that it would take longer to produce 60 $cm^3$ of hydrogen i.e. after 120 s.

**(d)** Some candidates gave the correct ionic equation with appropriate state symbols. Others tried to write molecular equations. Some of these tried to cancel the species but were left with a mixture of incorrect ions / molecules. A common error was to suggest that the silver ion has a 2+ charge.

**Question B9**

This question was the second least popular of the **Section B** questions. Many candidates gave good accounts of electrolysis and electron flow and could name an alloy containing copper. Many wrote a substantial amount for **(a)** and **(d)** but this did not always receive credit. Some candidates gave very vague answers about the structure of metals.

**(a)** A few candidates obtained full credit and gave accurate and concise answers including an excellent diagram. Others drew inaccurate diagrams, very often mislabelling them. Few scored the third marking point for the attractive force between the ions and the electrons. The commonest errors were to draw an irregular arrangement of ions, to call the ions atoms or protons, to space out the ions too far apart, to draw the electrons surrounding a group of positive ions with no electrons between the ions or to draw an ionic structure.

**(b)**

**(i)** This was generally answered very well, most candidates writing about freely moving electrons or a sea of electrons. A few candidates wrote, incorrectly, about moving ions.

**(ii)** Where candidates gained only partial credit they generally only mentioned the pure cathode and impure anode. Some candidates mentioned an impure copper anode only and did not make the corresponding statement about the cathode. Mentioning that the pure copper was plated onto the cathode was not sufficient.

**(c)** This was well answered, brass and bronze being the commonest correct answers. A few candidates simply wrote 'wires' or 'coins' which was insufficient for credit to be awarded.

**(d)** Many candidates gained partial credit for this part, generally for mentioning the limited supply of copper and reduction in pollution. A considerable proportion of the candidates answered the question by explaining why copper was important, giving its uses, rather than answering the question that was set. Some candidates gave negative answers for the copper electrolysis which should have applied to the extraction and purification of copper from its ore e.g. recycling copper is more polluting.

**Question B10**

Many candidates gave good answers to most parts of this question and the calculation was often well done. Parts **(a)** and **(c)(i)** were particularly well done.

**(a)** This was well answered by many candidates. Common errors were $CH_6O$, $C_3H_6O_3$ and writing the stoichiometric ratio without referring to the symbols of the atoms.

**(b)**

**(i)** Many candidates were able to write the formulae of the products and reactants. Fewer balanced them correctly. Common errors were lack of balance of oxygen, the addition of the word energy to the right hand side of the equation and attempting to balance using the number 3 in various places.

**(ii)** Many candidates gave good precise answers. Others gave rather more vague indications such as 'optimum temperature'. Other errors included light rather than sunlight and carbon dioxide and water (which are 'reactants' rather than conditions). Those who obtained full credit generally gave sunlight and chlorophyll.

**(c)**

**(i)** Many candidates gave good precise answers. As for **(b)(ii)** some gave rather vague indications such as 'optimum temperature'. The commonest correct answers were 'anaerobic conditions / absence of oxygen' and 'yeast'. Errors included giving high temperatures and pressures (a confusion here with the conditions for the hydration of ethene) or the presence of oxygen

**(ii)** The calculation was generally well done. Some candidates gave the answer in terms of grams but did not put the unit as grams. Candidates were more likely to obtain full credit when they followed the ratio method rather than the moles method.

**(iii)** A few candidates recognised that distillation was essential or that carbon dioxide was a greenhouse gas. Many gave answers that were vague, were concerned with financial implications or stated 'bad yield' without further qualification.

# CHEMISTRY

**Paper 5070/31**
**Practical Test**

## Key messages

- As always, candidates should be encouraged to read each question carefully before answering or starting any practical work.
- In quantitative experiments, candidates should repeat the experiment to achieve consistency and then average only the consistent results.
- In qualitative experiments, candidates should be reminded of the importance of making complete and accurate notes of their observations. When a gas is observed this gas should be tested, the observations of the test recorded and the gas identified.

## General comments

Most of the candidates were well prepared for the Test and demonstrated capable practical skills in completing the quantitative and qualitative exercises. Supervisors are thanked for providing the required experimental data to enable assessment of the candidates' work.

## Comments on specific questions

### Question 1

**(a)** Despite the procedure being unfamiliar, plenty of the candidates followed the instructions well and performed well on this question.

Full credit was awarded for obtaining two results within 0.2 $cm^3$ of the Supervisor's value, and then for averaging two or more results that did not differ by more than 0.2 $cm^3$.

The data was generally properly and precisely recorded in the table and candidates repeated the titration until they obtained consistent results. The titres, i.e. best titration results, were then ticked and accurately averaged. There were occasional candidates who did not tick any results or ticked only one and there were also a few others who, having correctly identified the best results, averaged all the titres regardless of their consistency.

A number of candidates skilfully processed their results and were awarded full credit in the questions that followed but there were many who made the same mistake in **(c)**. Virtually all the candidates attempted the questions and secured some reward, with the calculations being marked consequentially throughout.

**(b)** Most solutions showed the correct use of the molar ratio from the equation and provided answers for the concentration of iodine to 3 significant figures.

**(c)** Many candidates incorrectly calculated the mass of iodine in **P**, by multiplying the answer from **(b)** by 127, rather than 254.

**(d)** Despite the errors in **(c)** numerous candidates demonstrated good understanding of the information provided about parts per million, by determining the amount of iodine present in seaweed.

**Question 2**

Candidates managed their time well in that they completed all the tests. The most able candidates carefully followed instructions and recorded observations clearly using appropriate terminology. There were many others who showed the same competence at times but they were inconsistent in their approach. Consequently, credit could not be awarded for incomplete answers and inaccurate recording. When a gas is observed e.g. by the bubbling of a liquid, the gas should be tested and identified. There is no credit to be gained by simply writing the name of a gas, even if it is correct. When a liquid is added to a solid, it should be recorded whether the solid disappears or not e.g. if a precipitate remains or disappears when a solution is added. Teachers should continue to encourage candidates to make full use of the qualitative analysis notes supplied on the last page of the exam paper. The terminology and method of reporting provided are a model for the successful recording of observations.

It was not necessary to make all the observations to obtain full credit for this question.

**R** was hydrochloric acid **S** was sodium hydroxide

**Test 1** Most candidates recorded the bubbling but relatively few the disappearance of the solid. The gas was successfully tested by many using limewater which turned milky, and then further credit was secured by its identification as carbon dioxide.

**Test 2** Most candidates obtained credit for white precipitate in **(a)** but there was no credit for recording the liquid turns cloudy. The solid disappears when the ammonia is added and the final solution is colourless. There were a number of candidates who did not get the precipitate to disappear, presumably because they did not add sufficient ammonia to neutralise the acid.

**Test 3** As in **Test 1** most candidates recorded the bubbling but few the disappearance of the ribbon. While many successfully identified the hydrogen by writing 'pops with a lighted splint', there were some whose test was not properly reported e.g. a gas which pops, pops with a glowing splint and therefore did not receive credit. The exothermic nature of the reaction was noted on numerous occasions.

In **(b)** there is a white precipitate formed on adding **S** which is insoluble in excess. While many candidates recorded the white solid, they did not all indicate that it remains.

**Test 4** Most candidates reported the white precipitate formed by adding **S** and then found in excess the solid disappeared. While many recorded the final solution was colourless, some made no attempt to describe it or simply reinforced the dissolving by reporting it as clear.

**Test 5** In both **(a)** and **(b)** a green precipitate is produced which disappears in excess of the added solution to form a green solution. Performing the test correctly requires the solution to be added slowly with thorough mixing to the contents of the test-tube, particularly in **(b)** and creditably there were a number of candidates who did this and scored full credit.

However, there were some candidates who saw no solid formed at any stage, suggesting that they added the solution too quickly. As expected there were others who recorded the precipitate and its disappearance in **(a)** but not in **(b)**. Additionally, there was another group who produced a precipitate in **(a)** but only redissolved it when **R** was added in **(b)**.

**Test 6** Most candidates correctly recorded that a gas was produced on warming, which turned damp red litmus blue and identified it as ammonia, scoring full credit. There were a number of reports of effervescence, which were not penalised but suggested confusion between the bubbling caused by heating with that resulting from reaction.

**Conclusions**

Credit was most frequently awarded for identifying the anion in **R** as chloride.

While some candidates provided the identity of one of the other ions, there were relatively few who managed to correctly identify all three.

# CHEMISTRY

**Paper 5070/32**
**Practical Test**

## Key messages

- As always, candidates should be encouraged to read each question carefully before answering or starting any practical work.
- In quantitative experiments, candidates should repeat the experiment to achieve consistency and then average only the consistent results.
- In qualitative experiments, candidates should be reminded of the importance of making complete and accurate notes of their observations. When a gas is observed this gas should be tested, the observations of the test recorded and the gas identified.

## General comments

Most of the candidates were well prepared for the Test and demonstrated capable practical skills in completing the quantitative and qualitative exercises. Supervisors are thanked for providing the required experimental data to enable assessment of the candidates' work.

## Comments on specific questions

### Question 1

**(a)** Despite the procedure being unfamiliar, plenty of the candidates followed the instructions well and performed well on this question.

Full credit was awarded for obtaining two results within 0.2 $cm^3$ of the Supervisor's value, and then for averaging two or more results that did not differ by more than 0.2 $cm^3$.

The data was generally properly and precisely recorded in the table and candidates repeated the titration until they obtained consistent results. The titres, i.e. best titration results, were then ticked and accurately averaged. There were occasional candidates who did not tick any results or ticked only one and there were also a few others who, having correctly identified the best results, averaged all the titres regardless of their consistency.

A number of candidates skilfully processed their results and were awarded full credit in the questions that followed but there were many who made the same mistake in **(c)**. Virtually all the candidates attempted the questions and secured some reward, with the calculations being marked consequentially throughout.

**(b)** Most solutions showed the correct use of the molar ratio from the equation and provided answers for the concentration of iodine to 3 significant figures.

**(c)** Many candidates incorrectly calculated the mass of iodine in **P**, by multiplying the answer from **(b)** by 127, rather than 254.

**(d)** Despite the errors in **(c)** numerous candidates demonstrated good understanding of the information provided about parts per million, by determining the amount of iodine present in seaweed.

**Question 2**

Candidates managed their time well in that they completed all the tests. The most able candidates carefully followed instructions and recorded observations clearly using appropriate terminology. There were many others who showed the same competence at times but they were inconsistent in their approach. Consequently, credit could not be awarded for incomplete answers and inaccurate recording. When a gas is observed e.g. by the bubbling of a liquid, the gas should be tested and identified. There is no credit to be gained by simply writing the name of a gas, even if it is correct. When a liquid is added to a solid, it should be recorded whether the solid disappears or not e.g. if a precipitate remains or disappears when a solution is added. Teachers should continue to encourage candidates to make full use of the qualitative analysis notes supplied on the last page of the exam paper. The terminology and method of reporting provided are a model for the successful recording of observations.

It was not necessary to make all the observations to obtain full credit for this question.

**R** was hydrochloric acid **S** was sodium hydroxide

**Test 1** Most candidates recorded the bubbling but relatively few the disappearance of the solid. The gas was successfully tested by many using limewater which turned milky, and then further credit was secured by its identification as carbon dioxide.

**Test 2** Most candidates obtained credit for white precipitate in **(a)** but there was no credit for recording the liquid turns cloudy. The solid disappears when the ammonia is added and the final solution is colourless. There were a number of candidates who did not get the precipitate to disappear, presumably because they did not add sufficient ammonia to neutralise the acid.

**Test 3** As in **Test 1** most candidates recorded the bubbling but few the disappearance of the ribbon. While many successfully identified the hydrogen by writing 'pops with a lighted splint', there were some whose test was not properly reported e.g. a gas which pops, pops with a glowing splint and therefore did not receive credit. The exothermic nature of the reaction was noted on numerous occasions.

In **(b)** there is a white precipitate formed on adding **S** which is insoluble in excess. While many candidates recorded the white solid, they did not all indicate that it remains.

**Test 4** Most candidates reported the white precipitate formed by adding **S** and then found in excess the solid disappeared. While many recorded the final solution was colourless, some made no attempt to describe it or simply reinforced the dissolving by reporting it as clear.

**Test 5** In both **(a)** and **(b)** a green precipitate is produced which disappears in excess of the added solution to form a green solution. Performing the test correctly requires the solution to be added slowly with thorough mixing to the contents of the test-tube, particularly in **(b)** and creditably there were a number of candidates who did this and scored full credit.

However, there were some candidates who saw no solid formed at any stage, suggesting that they added the solution too quickly. As expected there were others who recorded the precipitate and its disappearance in **(a)** but not in **(b)**. Additionally, there was another group who produced a precipitate in **(a)** but only redissolved it when **R** was added in **(b)**.

**Test 6** Most candidates correctly recorded that a gas was produced on warming, which turned damp red litmus blue and identified it as ammonia, scoring full credit. There were a number of reports of effervescence, which were not penalised but suggested confusion between the bubbling caused by heating with that resulting from reaction.

**Conclusions**

Credit was most frequently awarded for identifying the anion in **R** as chloride.

While some candidates provided the identity of one of the other ions, there were relatively few who managed to correctly identify all three.

# CHEMISTRY

**Paper 5070/41**
**Alternative to Practical**

## Key messages

- Candidates should be advised to read the question carefully before answering.
- Candidates should be advised to attempt each question as credit cannot be given for blank answers.
- The number of marks shown and the amount of space provided give a guide to the length of answer required, and candidates who exceed the space provided may be wasting time giving unnecessary or irrelevant detail. It is helpful if candidates confine their answers to the space provided; if their answer continues elsewhere on the paper this should be made clear.

## General comments

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

Skills assessed include recognition and calibration of chemical apparatus and their uses, recall of experimental procedures, handling and interpretation of data, drawing of graphs, analysis of unknown salts and calculations. Many candidates showed evidence of possessing many of these skills.

Many candidates showed competency of plotting points accurately on graphs and joining the points as instructed. Many candidates were able to carry out accurate calculations using the appropriate significant figures.

It is highly recommended that candidates name chemicals using the names which are listed on the syllabus.

## Comments on specific questions

### Question 1

**(a)** The apparatus is a measuring cylinder containing **(b)** 24 $cm^3$. Most of the candidates answered these two parts well.

**(c)**

**(i)** Acids turn litmus red.

**(ii)** When an acid is added to a carbonate, bubbles, fizzing or effervescence is the best way to give an observation for what is seen. The solid carbonate also dissolves.

**(d)** The alcohol is ethanol, whose formula can be represented as $C_2H_5OH$ or $CH_3CH_2OH$.

### Question 2

**(a)(b)** Most of the candidates did the necessary subtractions to achieve the correct answers.

**(c)** Most of the candidates were able to calculate the correct formula masses of 136 and 18 respectively.

**(d)** The correct answer to this is 2. There were many correct responses. Candidates should realise that **x** has to be a whole number in order to represent a number of molecules.

**(e)** The preferred name given to compounds that have lost all their water of crystallisation is anhydrous, however, dehydrated is also acceptable as a correct answer. There were some who chose to describe the compound before it had lost its water of crystallisation as efflorescent and this too was credited.

**Question 3**

**(a)** Sulfuric acid improves the conductivity of the water. Some candidates focused on the use of the word 'small' and attempted to explain why only a small amount of acid was added, usually citing safety reasons. This was not credited.

**(b)(c)** It was not unusual to see oxygen and hydrogen produced at the wrong electrodes, nor was it unusual to see incorrect tests being given for both gases. A glowing splint, which relights or is rekindled, is used to test for oxygen, whereas a burning splint, which pops, is used to test for hydrogen.

**(d)** The volume of hydrogen collected at the cathode is twice the volume of oxygen collected at the anode i.e. $2 \times 20 = 40\ cm^3$

**Questions 4 to 8**

The correct answers are **(d)**, **(c)**, **(b)**, **(b)** and **(a)**.

**Question 9**

**(a)** The correct mass is 1.76 g.

**(b)** The colour change of phenolphthalein is pink in alkaline solution to colourless at the end point.

**(c)** The three correct titres are: 27.6, 27.1 and 27.3 $cm^3$, the mean being 27.2 $cm^3$ which is taken from the second and third titres. The majority of candidates were able to read the burettes correctly. A small number of candidates read the burettes upwards instead of downwards. It was not unusual to see 27.3 $cm^3$ given as the mean.

Throughout this question any incorrect answer could be used in subsequent parts as error carried forward and gain credit accordingly. For example if **(d)** was incorrect, **(e)** would gain credit if it was the same as **(d)**.

Because **(f)** was often larger than **(g)**, candidates often subtracted **(f)** from **(g)** instead of **(g)** from **(f)** to calculate the answer to **(h)** to avoid a negative answer.

**(j)** Ammonium nitrate, (a salt), is produced by reacting ammonia (an alkali) with nitric acid (an acid).

**(k)** The mass of nitrogen is correctly calculated by $28/80 \times 1000 = 350$ g. Those who only saw one nitrogen atom in the formula of $NH_4NO_3$ achieved the incorrect answer of 175 g, which was not uncommon.

**Question 10**

**(a)** Because **Y** is a compound of a transition metal, a solution of **Y** will be coloured.

**(b)(c)** Not all candidates realised that the observations column had to be completed for excess as well as the conclusion column.

**(d)** The test for nitrates in solution is to add aqueous sodium hydroxide followed by aluminium. The mixture is warmed gently. Ammonia gas, which turns damp red litmus paper blue, is given off. The brown ring test was also credited. Some candidates described this correctly.

**Question 11**

**(a)** The missing volumes in the table were 32, 52, 64 and 70 $cm^3$ all of which the majority of candidates were able to record correctly.

**(b)** Most candidates showed competency of plotting points accurately on graphs and drawing two smooth curves as instructed though not all the curves started at 0,0.

**(c)**

**(i)** Large numbers of candidates were able to read off a volume of approximately 32 $cm^3$ by reading off the volume at 45 seconds, although a small number read off the volume at the wrong point.

**(ii)** Candidates were expected to read off the volumes at 75 seconds and then to subtract the lower volume from the higher volume. If the graph was read from the wrong point it was still possible to gain credit for subtraction if working out was shown.

**(d)** The copper(II) oxide is a catalyst.

**(e)** Many thought that this question was referring to both experiments and not only to experiment 2. A common answer was that the mass of potassium chlorate(V) was the same in both experiments. It was expected that candidates would realise that all the potassium chlorate was used up when no more gas was evolved.

**(f)** Those who did not convert $cm^3$ into $dm^3$ or vice versa achieved an incorrect answer of 245 g, which received partial credit. Working out should be shown clearly in all calculations. Not all candidates realised that 72 $cm^3$ had to be extracted from the table.

# CHEMISTRY

**Paper 5070/42**
**Alternative to Practical**

## Key messages

- Candidates should be advised to read the question carefully before answering.
- Candidates should be advised to attempt each question as credit cannot be given for blank answers.
- The number of marks shown and the amount of space provided give a guide to the length of answer required, and candidates who exceed the space provided may be wasting time giving unnecessary or irrelevant detail. It is helpful if candidates confine their answers to the space provided; if their answer continues elsewhere on the paper this should be made clear.

## General Comments

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

Skills include recognition and calibration of chemical apparatus and their uses, recall of experimental procedures, handling and interpretation of data, drawing of graphs, analysis of unknown salts and calculations.

The standard continues to be maintained and the majority of candidates show evidence of possessing many of the aforementioned skills.

Most candidates show competency of plotting points accurately on graphs and joining the points as instructed.

Calculations are generally completed successfully using the appropriate significant figures.

## Comments on Specific Questions

### Question 1

**(a)** The volume of gas in the syringe is 46 $cm^3$.

**(b)** The volume of gas will be less during the second minute. This may be explained by referring to the reducing concentration or mass of the reactants as the reaction proceeds.

**(c)** A common error was not using the mole ratio of calcium carbonate to hydrochloric acid as 1:2 in the calculations **(iii)** and **(iv)**.

Candidates who gave the answer to **(iv)** as 0.12 were awarded credit so long as $dm^3$ was stated as the unit.

**(d)** Answers to **(i)** and **(ii)** must relate to the original state or concentration of the two reactants. Answers such as small particles in **(i)** and concentrated in **(ii)** did not receive credit.

**(e)** Other ways of increasing the rate include heating the reacting mixture or using a catalyst.

**Question 2**

**(a)** Aqueous copper(II) sulfate is blue.

**(b)**

**(i)** A colour change was not seen in cell **B**.

**(ii)** The emphasis here must be on observations, not on theoretical answers such as half equations involving ions. Most were able to describe these observations in terms of how the mass of each electrode changed or by observing that copper is deposited on the cathode and removed from the anode.

**(iii)** The colour of the solution is maintained as the concentration of aqueous copper ions remains constant. Alternatively candidates could suggest that the rate of deposition of copper at the cathode is equal to the rate at which it is removed from the anode.

**(c)**

**(i)** The colour of the solution in the other cell fades or becomes colourless.

**(ii)(iii)** Oxygen is evolved at electrode **H** and is confirmed by relighting a glowing splint. Many candidates continue to confuse the tests for oxygen and hydrogen.

**(iv)** Copper or a pink deposit is seen at the other electrode.

Candidates who incorrectly suggest that the colour change is not seen in cell **A** may gain credit consequentially for correct answers to **(b)(ii), (c)(i), (iii)** and **(iv)**.

**Questions 3 to 7**

Correct answers to the multiple choice **Questions** are **(a), (c), (c), (d)** and **(b)** respectively.

Candidates generally scored well on these questions.

**Question 8**

**(a)** Correct answers include iron(III) ions cannot be further oxidised or are oxidising agents or are not reducing agents. It is encouraging to note that many candidates were able to give correct answers to this question.

**(b)** 5.08 g of the iron(II) / iron(III) mixture are used in the experiment.

**(c)** A pipette should be used. Various spellings of pipette were seen but credit was generally awarded.

**(d)** Acceptable colour changes are colourless, green or yellow to pink. A final colour of purple, although acceptable, should be discouraged as it suggests that the titration has gone past the end-point.

**(e)** The correct titres are 26.3, 25.8 and 25.6 $cm^3$ respectively giving a mean titre of 25.7 $cm^3$. In cases where errors in reading the burette diagrams give different titres, the mean must be taken from the closest two titres and indicated by ticks in the appropriate places.

Answers to the calculations are:

**(f)** 0.00046 moles

**(g)** 0.0023 moles

**(h)**

**(i)** 0.023 moles

**(ii)** 3.52 g

**(i)** 692 g /1000 g

An incorrect answer may be used in subsequent calculations and if correct may score the available credit.

Most candidates answered this question well, giving correct answers to most parts of the question.

**Question 9**

**(a)** A colourless solution confirms the absence of a transition metal in an aqueous solution of **V**. Statements that **V** or 'it' is not a transition metal were not awarded credit.

**(b)** The test involves the addition of aqueous sodium hydroxide in **(i)** and **(ii)** the addition of excess aqueous sodium hydroxide. Sodium hydroxide must be described as aqueous, dilute or solution in either or both **(i)** or **(ii)**.

A white precipitate in **(i)**, insoluble in excess in **(ii)**, should be observed.

**(c)** The addition of aqueous ammonia produces either a slight white precipitate or no precipitate. Observations such as no reaction or no change were not awarded credit.

**(d)** The test for the nitrate ion involves heating with aqueous sodium hydroxide and aluminium to produce ammonia or a gas that turns red litmus blue.

The very few candidates who suggested the 'Brown Ring' test were credited.

When nitric acid or ammonia is used as part of the test solution credit could not be awarded.

**Question 10**

**(a)** Barium sulfate is a white precipitate.

**(b)** The correct masses of precipitate are 0.58, 1.05, 1.75, 2.33, 2.33, 2.33 g

**(c)** Candidates are asked to plot these masses on the grid. The points should be connected by two intersecting straight lines. The sloping line should pass through zero and intersect at the upper end with a horizontal straight line through the three points 2.33 g. Credit could not be awarded for incorrect plotting of one or more points and not extending the sloping line through zero.

Most candidates completed the graph successfully, however many candidates incorrectly plotted the point 0.58 at 0.90 on the graph, having misinterpreted the scale on the *y*-axis. This was a little surprising as most of these candidates correctly plotted the remainder of the points. The point 2.33 g was often plotted inaccurately.

The use of a ruler is essential in connecting the points on the graph.

**(d)** The incorrect point is 1.05 g. This point should be ringed on the graph and correctly read as 1.15 g. However candidates may choose a different point which may have resulted from incorrect plotting of points on the graph. This often occurred as a result of the incorrect plotting of the point 0.58 at 0.90 as previously mentioned in **(c)**.

**(e)** For answers to **(i), (ii)** and **(iii)** candidates should read their own graph.

Correct answers are **(i)** 5.2 $cm^3$, **(ii)** 2.33 g and **(iii)** 8.0 $cm^3$.

**(f)** A correctly balanced equation should be used in combination with the answer **(e)(iii)** to give an answer **(f)** of 1.25 mol/$dm^3$.

In all appropriate cases credit may be awarded for any error which is correctly used in subsequent parts to the question.

Examples include incorrect lines on the graph resulting from one or more incorrectly plotted points and when the two lines do not intersect at 8.0 $cm^3$.

Most candidates scored well on the graphical answers but, in general, found difficulty with the final calculation.