CHEMISTRY

Paper 5070/11
Multiple Choice

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

General Comments

Candidates found questions **1** and **39** the most straightforward and the remainder of the paper was a good test of the candidates' knowledge and ability.

Comments on Specific Questions

Question 8

Magnesium oxide and aluminium oxide are both ionic compounds and therefore conduct electricity when molten. The temperature range over which both compounds are molten is 2852 to 2880 $^{\circ}$C.

Question 15

Zinc is above copper in the reactivity series and therefore zinc is the metal which ionises in the cell shown in the question.

Question 18

In the reaction between iron(II) sulfate and sodium hydroxide, none of the elements gained or lost electrons. In all the other reactions elements gained or lost electrons.

Question 23

Calcium proved a strong distractor in this question. The metals calcium and strontium are both in Group II of the Periodic Table and have similar reactions and in their reactions they lose their two outer electrons. However, strontium ions and calcium atoms do not have the same electronic configuration.

Question 28

Candidates choosing alternative **B** concentrated their attention solely on the equations showing the discharge of ions during the electrolysis of aluminium oxide. However one other reaction, namely the formation of carbon dioxide, takes place at the positive electrode.

Question 34

Only sulfur dioxide in the list of gases was an acidic gas and able to react with limestone.

Question 38

The only structure without a CH_3 group in it was more popular with the candidates than the correct answer **A**.

CHEMISTRY

Paper 5070/12
Multiple Choice

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

General Comments

Five questions namely **2**, **7**, **8**, **37** and **39** had very high success rates. Conversely, questions **19** and **35** proved difficult and candidates were split between the four alternatives. Over all the paper distinguished well between the candidates and proved to be a good test of their chemical knowledge.

Comments on Specific Questions

Question 12

Answers to this question were split between alternatives **C** and **D**. The key to obtaining the correct answer (**D**) was the realisation that chlorine exists as molecules in the gaseous state.

Question 19

Sodium hydroxide is an alkali and reacts with the acidic oxide, carbon dioxide, a fact well known by the majority of the candidates. Many did not realise that the amphoteric oxide, aluminium oxide, also reacts with sodium hydroxide.

Question 27

Iron and calcium silicate both settle at the bottom of the Blast Furnace in the liquid state due to the high temperature of the furnace. The iron is not in the solid state as suggested in distractor **D**.

Question 28

Nitrogen is almost inert and does not react with copper(II) oxide or sodium hydroxide. The only gas passing unchanged through the apparatus had to be nitrogen. Thus **Z** was nitrogen and **A** was the only alternative with **Z** identified as nitrogen.

Question 31

Candidates choosing alternative **B** concentrated their attention solely on the equations showing the discharge of ions during the electrolysis of aluminium oxide. However one other reaction, namely the formation of carbon dioxide, takes place at the positive electrode.

Question 34

The most popular distractor was **C**, filtration. Filtration is a process used to separate insoluble solids from a liquid. Thus filtration would not remove salt, a soluble compound, from sea water.

Question 35

Alternatives **C** was almost as popular as the key, **A**. Candidates opting for **C** did not take into account that **A**, CH_3OH, contained oxygen already and **C**, C_3H_8, did not.

CHEMISTRY

Paper 5070/21

Theory

Key Messages

To be successful in calculations candidates must organise their answers in a clear and coherent way. Candidates found the short answer questions less challenging than those which required longer answers. To improve performance on the latter, it is suggested that candidates answer by using bullet points rather than long paragraphs in order to better organise their thoughts. Candidates often found it difficult to construct equations involving ions.

General Comments

Candidates appeared to have sufficient time to compete this examination paper. Most candidates followed the rubric of the question paper and attempted just three questions from ***Section B***.

Good answers to questions used the correct chemical terms but many candidates gave imprecise answers to questions that needed a longer response.

Candidates often did not organise their answers to quantitative questions which made it difficult to award marks for errors carried forward. Candidates should be advised to show all the steps in a calculation so that Examiners can easily credit the working out.

Comments on Specific Questions

Section A

Question A1

(a) Some candidates were able to identify iron(II) hydroxide but a common error was copper(II) nitrate.

(b) Many candidates recognised butane as a saturated hydrocarbon but a common error was propene.

(c) Some candidates identified propene as a molecule containing nine atoms but other candidates included some of the ionic compounds. In particular copper(II) nitrate was a popular incorrect choice.

(d) Some candidates selected calcium carbonate as a substance used to reduce the acidity in lakes. Common incorrect responses included iron(II) hydroxide and iron(III) hydroxide.

(e) Some candidates recognised that sulfur dioxide would give an orange to green colour change with aqueous potassium dichromate(VI).

(f) Many candidates selected either sodium chloride or sulfuric acid, the correct responses.

Question A2

This question was about photosynthesis.

(a) The percentage of oxygen in dry air was well known.

(b) Candidates could often recall the overall equation for photosynthesis. Some candidates included energy and/or ATP in the equation, this was not given credit. References to chlorophyll or sunlight over the arrow were ignored.

(c) The conditions needed for photosynthesis were well known. Some candidates could not distinguish between reactants and the conditions needed and as a result included carbon dioxide as a condition. The mark scheme allowed water as a condition since all the reactions take place in an aqueous solution. The most common correct conditions were sunlight and the presence of chlorophyll. Not many candidates referred to the presence of enzymes.

(d) (i) Candidates answered this question with much more confidence than in previous sessions, and there were far fewer references to bond making needing energy. Good answers stated that bond breaking was endothermic and bond making was exothermic and then in a second sentence explained that less energy was released than absorbed.

(ii) Many candidates could draw a correct energy profile diagram but were less certain when it came to labelling the energy changes. Typically the activation energy was done better than the enthalpy change. Often the enthalpy change had the arrow in the wrong direction. Candidates found the endothermic energy profile much more difficult to label than an exothermic energy profile.

Question A3

This question was about the neutralisation of acids by bases.

(a) (i) Some candidates could write the balanced equation although a significant proportion gave the wrong formula for potassium sulfate.

(ii) Many candidates could interpret the graph and deduced that 24 cm^3 of potassium hydroxide neutralised the acid. A small proportion of candidates gave a volume of around 39 cm^3 where the graph levelled out.

(iii) This question had credit for error carried forward from both parts **(i)** and **(ii)** however many candidates did not show their working out or it was so confused it was not possible to see if there was any credit from error carried forward. A significant proportion of candidates confused the volumes of acid with the volume of alkali. Good answers gave logical working out and obtained the correct answer of 0.072 mol/dm^3.

(b) Candidates found the preparation of zinc nitrate from zinc oxide extremely challenging. Many candidates used a titration method to make this salt. Other candidates used a precipitation method. Only a small proportion of the candidates described the correct preparation using an insoluble base and dilute nitric acid. Typically candidates scored a mark for appreciating that nitric acid was needed and sometimes for describing how to obtain crystals from aqueous zinc nitrate

Question A4

This question was about the number of sub-atomic particles in different atoms and ions.

(a) Some candidates were able to deduce that the nucleon number was 40.

(b) Candidates did not always specify that the charge on an atom depends on the number of protons and electrons. A significant proportion of candidates explained this in terms of the equal number of neutrons and protons (or electrons). Many candidates also forgot to mention the charges on protons and electrons.

(c) Candidates often recognised **C** and **D** as isotopes, however some gave **D** and **G**.

(d) While candidates often recognised that **E** was negatively charged not all stated it was -2.

(e) Candidates found this question quite demanding and did not always realise that that it was connected to the sum of the neutrons and the protons.

Question A5

This question was about ammonium dichromate(VI).

(a) Candidates were able to show that the formula was $(NH_4)_2Cr_2O_7$ but sometimes they did not show all the required working out. Only a small proportion of candidates worked out the percentage composition from the formula and showed that it was the same as that given in the stem of the question.

(b) Chromium was often recognised by candidates as the element that was responsible for the colour of ammonium dichromate(VI).

(c) Many candidates deduced that the compound was an oxidising agent but few candidates could explain why, in terms of the change of oxidation state of iodine or the loss or gain of electrons.

(d) (i) Candidates often recognised the presence of an ammonium ion although there was some confusion with aluminium ions.

(ii) Candidates found this question very challenging and rarely gave the correct formula of $Cr_2O_7^{2-}$.

(e) A large variety of compounds containing nitrogen were given as answers including, ammonia, nitrogen dioxide and nitric oxide. Only a small number gave the correct answer of nitrogen. There was very little evidence of candidates trying to write an equation and deducing that there were two nitrogen atoms left which must be the last product.

Question A6

This question was about potassium and chlorine.

(a) (i) Although some candidates could draw the correct ‘dot-and-cross’ diagram many candidates drew incorrect diagrams with the outer electrons missing from one or more atoms and only the shared pairs of electrons being drawn. Most candidates attempted to draw diagrams with the atoms in the correct order of C*l*-O-C*l* and only a small proportion of candidates drew ionic ‘dot-and-cross’ diagrams.

(ii) Candidates found this question extremely challenging and rarely described weak intermolecular forces. Typical misconceptions included weak covalent bonds or weak forces between atoms.

(b) Candidates often drew just the outer shell electrons even though the question asked for the electronic configuration. Other candidates gave the correct electronic structures and either forgot the charges or wrote down the wrong charges.

(c) Some candidates were able to write the correct equation using the molar ratios given. Other candidates tried to write equations with HC*l* and ignored the information in the stem.

Section B

Question B7

This question focused on malachite.

(a) Candidates found this question difficult and often only mentioned the formation of gas bubbles. Some candidates added information about testing the gas with limewater which was not required by the mark scheme. Candidates were not given credit for reference to a gas being given off since the question specifically asked for an observation. Most candidates did not describe what happened to the mixture in terms of forming a blue solution.

(b) Candidates found this equation extremely challenging and many were not able to give the correct formulae of the products.

(c) Candidates did not always organise their answers and often presented a collection of numbers and numerical expressions with no explanation about what they were trying to do. Only a very small number of candidates got the correct answer of 0.24 g.

(d) (i) Candidates found this equation extremely challenging and many were not able to give the correct formulae of the products.

(ii) Candidates often just expanded on the stem in terms of the finite nature of malachite. The most popular correct answers focused on less waste and reducing use of landfill sites

Question B8

This question focused on the homologous series of carboxylic acids.

(a) Candidates often appreciated that members of a homologous series had the same chemical reactions, though candidates rarely referred to the term functional group. Candidates also appreciated that members of a homologous series have a general formula or have successive members that varied by CH_2.

(b) Propanoic acid was well known although a few candidates referred to pentanoic acid.

(c) The general formula for a carboxylic acid was deduced by many candidates, however candidates had to include either COOH or CO_2H in the general formula rather than just a general molecular formula.

(d) Many candidates did not make two statements, one for boiling point and one for melting point. Candidates needed to appreciate that there was a trend in the boiling point whereas the melting point did not appear to have a trend.

(e) Candidates rarely got both the name and the structure of the ester correct. Some candidates reversed the ester quoting butyl ethanoate rather than ethyl butanoate. A typical error was to miss out one of the oxygen atoms in the ester and end up having a ketone structure.

(f) (i) Candidates could often define a weak acid in terms of partial dissociation but found writing the equation more difficult. Candidates often could not deduce the formula of the hexadecanoate ion.

(ii) Some candidates wrote an equation showing the formation of the salt and this was given credit. The most common error was to miss out an oxygen atom giving the formula as $C_{15}H_{31}CONa$.

Question B9

This question focused on the hydration of ethene.

(a) (i) Candidates often confused rate of reaction and position of equilibrium and as a result gave answers that referred to a lower rate of reaction because the reaction was exothermic. Other candidates just referred to the number of collisions or collision frequency rather than focusing on the speed of particles and the number of successful collisions. The best answers appreciated that the rate of reaction increased because there were more successful collisions.

(ii) Candidates expressed the idea that the position of equilibrium moved to the left in a variety of ways and often described the backward reaction being favoured. The best answers referred to the reaction being exothermic so the position of equilibrium moves to the left.

(b) (i) Candidates often did not appreciate that the particles would be less crowded and that as a result the collision frequency decreases. Candidates often did not include the idea of collision frequency and just referred to the number of collisions. Other candidates linked the rate of reaction with le Chatelier's principle.

(ii) As in **(a)(ii)** candidates expressed the idea that the position of equilibrium moved to the left in a variety of ways. Only the best answers linked this to the reactants having the greater number of moles.

(c) Some candidates were able to calculate the energy released as 450 kJ.

(d) Often candidates not only referred to the lowering of the activation energy but described the idea of an alternative pathway.

Question B10

This question focused on the electrolysis of aqueous silver nitrate.

(a) (i) Candidates who could recall the formula of a silver ion were likely to be able to write the cathode reaction. A common misconception was to give the formula of a silver ion as Ag^{3+} or Ag^{2+}.

(ii) Many candidates were able to recognise that silver ions gain electrons. Other candidates referred to the correct change in oxidation numbers and this was also given credit in the mark scheme. Some candidates were careless and referred to silver gaining electrons rather than silver ions.

(b) Typically candidates were able to get two of the marking points by stating that temperature and concentration do not affect the mass of silver made. Although candidates often recognised that the other two factors affected the mass of silver they did not give a precise description of the relationship i.e. that the current used and the duration were both directly proportional to the mass of silver produced. Other candidates gave answers that did not use the data but considered the factors in terms of rate of reaction.

(c) Some candidates appreciated the significance of ions as the charge carrier but a significant proportion of the candidates used electrons as the charge carrier. Another misconception was that solid silver nitrate does not contain ions.

(d) Candidate rarely could write the ionic equation and even if they did often left the state symbols out. Most candidates wrote full equations. A typical misconception was to have the formula of silver chloride as $AgCl_2$.

CHEMISTRY

Paper 5070/22

Theory

Key Messages

- Basic knowledge of simple organic chemistry was good. More practice is required in writing the formulae of esters.
- The construction of ionic equations needs more practice.
- A greater accuracy is required in the correct use of scientific terms in questions involving specific particles such as ions, molecules and atoms.
- Many candidates need to revise the differences between the particle structure and motion in solids and liquids and to distinguish between bulk properties and microscopic (particle) properties.
- In questions involving equilibrium reactions, a clear distinction needs to be made between questions involving rate and questions involving extent and direction of the equilibrium.
- Calculations, in both ***sections A*** and ***B***, were done well by many candidates. Others need to take care with the application of significant figures and ensure that working is clearly set out and molecular masses written down rather than left as a set of additions of atomic masses.

General comments

Many candidates tackled this paper well and gained good marks in ***section A***. Many candidates performed equally well in ***section B***. Candidates often lost marks by not answering the question set. For example, in **Question B9(c)(i)** many candidates wrote about rates of reaction when the stem of the question clearly stated the fact that the effect on equilibrium was required.

Many candidates performed well in questions involving calculations. Some showed appropriate working and clear indications about what each number referred to. Others can improve their score by making clear why they are performing certain steps. The answers to each stage of a calculation should also be shown, as should the results of addition to find relative molecular masses. Some relatively low scoring candidates were able to gain high marks for some of the calculations because their working was shown clearly.

The writing of balanced equations was not always successful, a major obstacle for some candidates being to work out the formula of simple species such as magnesium chloride and silver chloride. Ionic equations provided particular difficulties. More practice is required in constructing these. In **B10(c)** most candidates wrote a molecular equation rather than an ionic equation.

Candidates often found it difficult to gain marks for answers that required extended prose e.g. **A2(c)(i)**, **A3(a)**, **B7(c)** and **B9(a)** and **(b)**. Some candidates disadvantaged themselves by writing answers that were not sufficiently scientific. This was especially apparent in questions on equilibrium, particle theory and valency. Many candidates require more practice in questions involving particle theory, especially the difference between solid and liquids in terms of proximity, arrangement and motion of the particles; and the nature of metals, ionic substances and molecules in terms of the type of particles they contain i.e. ions, electrons, atoms and molecules.

Aspects of inorganic chemistry were generally well answered, especially in **Question A1**. Candidates did less well in inorganic questions where the compounds were unfamiliar e.g. **Question A5**. Many candidates performed well on questions about organic chemistry (**Questions A4** and **B8**). The main areas that require more practice in organic chemistry are **(i)** writing structures of esters and **(ii)** deducing structures of polymers from a given monomer.

Practical aspects of chemistry e.g. **Question B7(a)** were generally well done.

Comments on specific questions

Section A

Question A1

This question was well answered. The greatest number of errors was seen in part **(a)**.

(a) Over half the candidates gave the correct answer, sulfur. The most common incorrect answer was carbon.

(b) Nearly all the candidates suggested the correct answer – iron.

(c) A majority of the candidates selected calcium. Iron, copper or zinc were more rarely suggested. The most common error was to select carbon. Sulfur was occasionally seen as an incorrect answer.

(d) Most candidates selected carbon as the correct answer.

(e) Barium was often correctly given as the answer. The most common incorrect answers were calcium and lead.

(f) Lithium and calcium were the correct answers most often chosen. Zinc was the most common incorrect answer.

Question A2

Most candidates knew the overall equation for photosynthesis but many added energy or heat as a product of the equation. Part **(c)(i)** about bond breaking and bond making in an exothermic reaction was reasonably well done. A significant number of candidates confused the relationship between energy changes and bond breaking and formation. Many could draw an energy profile diagram for an exothermic reaction.

(a) Most candidates referred to the formation of carbon dioxide or the finite nature of fossil fuels. Some candidates gave non-specific answers that referred to air pollution. A significant minority referred incorrectly to ozone depletion.

(b) Many candidates could reproduce the overall equation for respiration. The most common error was to include heat or energy in the equation. Other common errors included: the inclusion of alcohol as a product; the omission of oxygen as a 'reactant'; incorrect balancing (often with $3O_2$ or $3CO_2$ and $3H_2O$)

(c) (i) In comparison with previous series, more candidates gave good answers. There was far less reference to bond making needing energy than in previous series. Good answers stated that bond breaking is endothermic and bond making exothermic and then explained that more energy is released than absorbed. Other candidates did not gain marks because they contradicted themselves when writing about energy absorbed and released.

(ii) Many candidates could draw a correct energy profile diagram. The main errors arose from the enthalpy change. Many candidates drew double-headed arrows or a line without arrows for the enthalpy change. The activation energy was drawn better than the enthalpy change. Some candidates drew the arrows too short or too long to be credited with marks, especially the arrow for the activation energy.

Question A3

Some candidates gave good, detailed answers to parts **(a)** and **(b)** of this question. Others wrote vague statements or did not find the correct words or phrases to answer these two parts. In part **(e)(ii)** few candidates understood that the properties of the aluminium oxide layer were required for a full answer. Good 'dot-and-cross' diagrams for iodine bromide were drawn by many candidates. The test for unsaturation was well known.

(a) Many candidates gained one mark for this question but very few gained both marks. Many did not state the number of valence electrons for both aluminium and iodine or bromine. Instead they gave a more generalised answer referring to metals having less than 4 valency electrons and non-metals having 4 or more valency electrons. Most realised that metals lose electrons to form ions and non-metals gain electrons. Others made general statements about metals and non-metals in the periodic table.

(b) Many candidates did not refer to the regular, ordered arrangement of the particles in the solid and irregular arrangement in the liquid and most did not know the difference between the proximity of particles and their arrangement. Candidates were more likely to be awarded marks for describing the difference in the motion of the particles.

(c) Most candidates drew the 'dot-and-cross' diagram successfully. The main errors were: leaving out the lone pairs of electrons; drawing two bonding pairs of electrons.

(d) Most candidates realised that bromine is decolourised by unsaturated compounds. A minority of candidates gave answers that referred to saturated compounds giving this colour change or stating, incorrectly, that bromine changed to red-brown when added to an unsaturated compound.

(e) (i) Many candidates did not mention low density, often writing 'light' or 'lightweight' instead.

(ii) Most candidates wrote about a layer of aluminium oxide or an oxide layer but many did not explain its importance in terms of it being unreactive or impermeable. Some candidates referred to a layer of oxygen rather than aluminium oxide. Many just referred to protection of the aluminium without mentioning the properties of the oxide layer.

Question A4

In parts **(a)** and **(b)**, most candidates recalled that fractional distillation depended on boiling points and showed good ability at writing a balanced equation for cracking. Many candidates need further practice at writing polymer structures from a given monomer. In part **(d)** some candidates did not read the stem of the question sufficiently well and omitted the reagents required to make ethanol.

(a) The process of fractional distillation was well known as was the importance of boiling point for this process. A minority of candidates referred incorrectly to melting points or cracking.

(b) Most candidates gave the correct formula for octane and could write a balanced equation. The equation most often seen was $C_{16}H_{24} \rightarrow C_8H_{18} + C_8H_{16}$. A few candidates showed hydrogen as a product. A few did not read the stem of the question properly and wrote species other than octane as products.

(c) Many candidates gave a structure that resembled poly(ethene) rather than poly(propene). Chains with occasional double bonds were not uncommonly seen. Most candidates did include the continuation bonds even when the structure of the polymer was incorrect.

(d) Very few candidates scored both marks for this question. A significant number did not include the reactants in their answer and just gave the conditions. Ethene or ethanol were not uncommonly seen as incorrect reagents. Most candidates gave phosphoric acid as the catalyst and a temperature of $300^{o}C$.

Question A5

This was one of the lowest scoring questions in the paper. Those candidates who worked their way through the question carefully and were not put off by the unfamiliar nature of the compound scored well. Most candidates did not score well in parts **(c)**, **(d)** and **(e)** because they seemed not to consider the formula of the compound and the fact that vanadium is a transition element.

(a) Many candidates were able to demonstrate from percentage composition data that formula was NH_4VO_3. Not all showed the required working. Many did not demonstrate the division by the smallest number in the second stage of the calculation. A small proportion of the candidates worked out the % composition from the formula and showed that it was the same as that given in the stem of the question.

(b) A significant number of candidates suggested, correctly, that the compound would be coloured. A common error was to write about properties of transition metals especially good ‘conductor’ and ‘high melting point’, rather than a property of their compounds.

(c) A minority of the candidates gained one mark. Very few gained two. Many candidates did not recognise the presence of NH_4^+ and hardly any worked out that the other ion present was VO_3^-. Common errors were: NH_3^+ or NH_4 instead of NH_4^+; NO_3^- (as the counter-ion to NH_4^+); V^{5+}. A small number wrote the formula for aluminium ions instead of the formula for ammonium ions.

(d) Some candidates deduced that the compound was an oxidising agent but few could explain why in terms of electron gain or oxidation number change. Many candidates suggested, incorrectly that **X** was more reactive or displacement took place. A significant number suggested that the reaction was an acid-base reaction.

(e) Some candidates recognised that ammonia gas is formed when the compound was heated. A large variety of incorrect elements or compounds of nitrogen were given as answers, the commonest of which were nitrogen dioxide, nitrogen oxide (NO) nitrogen. A few suggested compounds without nitrogen e.g. carbon dioxide.

Question A6

Many candidates scored well on this question. Most candidates had a good knowledge of redox chemistry and reactivity in parts **(a)** and **(d)**. The calculation in part **(b)** was well done by many candidates and generally well set out. Fewer candidates were able to deduce the colour changes in part **(c)**.

(a) Many candidates recognised that, in the equation, iron loses electrons. Others ignored the ‘explain using electron transfer’ in the stem of the question and only mentioned oxidation numbers. A considerable minority suggested that iron gains electrons.

(b) Most candidates were able to work out that iron was in excess. Most worked out the moles of iron and moles of copper. Others worked out the moles of copper sulfate, mass of copper sulfate and hence the mass of iron needed for the reaction. Some lost marks through rounding down the number of significant figures in the calculation of moles of iron or copper. Others just worked out the amount of one elements without reference to the other. A considerable minority of candidates stated incorrectly that copper is in excess although they demonstrated that there were more moles of iron.

(c) Many candidates gave the observation about the formation of a pink solid. Others suggested that a grey solid was formed. Fewer were able to describe what happened to the solution. The best answers referred to the blue solution becoming green. A considerable number of candidates suggested incorrectly that a green precipitate was formed or that the solution decolourised. Some candidates named the compounds formed rather than giving observations.

(d) Many candidates deduced that the reaction would take place and realised that copper is more reactive than silver. A significant number of candidates suggested, incorrectly, that the reaction would not take place and thought that silver was more reactive than copper.

Section B

Question B7

Many candidates drew good, well-labelled diagrams of a gas syringe attached to suitable apparatus in part **(a)** and balanced the equations in part **(b)(i)** correctly. A considerable proportion of the candidates did not use the graph to aid their calculations in part **(b)(ii)** although many gained error carried forward marks in part **(b)(iii)**. Few candidates gave convincing explanations for the increase in the rate of reaction in part **(c)**.

(a) Most candidates were able to draw a diagram that typically included a gas syringe. Sometime the apparatus would not work because of lack of stoppers or taps to thistle funnels. A minority of candidates just drew gas syringes or measuring cylinders without any connecting tubes or flask.

(b) (i) Most were able to balance the equations if they wrote the correct formulae. The formulae for calcium chloride and magnesium chloride were not always correct, $CaCl$ and $MgCl$ being common errors. In the first equation, the water was often left unbalanced.

(ii) A large number of candidates did not read off the volume of carbon dioxide from the graph and as a result did not calculate the amount of carbon dioxide made. Many candidates tried to work out the number of moles without using 24 000 or volume. These candidates tried to use the data at the head of the question.

(iii) Some candidates could calculate the mass of calcium carbonate. Others did not know how to complete the calculation. Many candidates did not include clear working and as a result it was often difficult to spot if the relative formula masses of the calcium carbonate had been correctly calculated.

(c) A majority of the candidates did not appreciate that the particles would be more crowded or there were more particles per unit volume. A greater number of candidates gained the ‘frequency of collisions’ mark. Others did not include the idea of frequency and just referred to ‘more collisions’ rather than ‘more collisions per second’ or ‘more frequent collisions’.

Question B8

This was the best answered of the part **B** questions. Part **(d)** (analysis of melting point and density trends) and part **(f)** (oxidation of ethanol) proved to be the most difficult parts.

(a) The presence of the OH group in alcohols was well known. A minority of candidates referred to OH^- or wrote hydroxide.

(b) The name of the three-carbon alcohol, propanol, was well known. The most common errors were to suggest propenol, pentanol or propanal.

(c) (i) The general formula of an alcohol was deduced by most candidates. A few incorrectly added an extra hydrogen and wrote $C_nH_{2n+2}OH$.

(ii) The formula of decanol was well known though a few candidates added an extra hydrogen to give the incorrect formula $C_{10}H_{22}OH$. A considerable minority of candidates gave the formula for pentanol even though they had got part **(c)(i)** correct. A few wrote formulae for hydrocarbons.

(d) About a third of the candidates stated the difference in the pattern of melting point and density. Many candidates did not write down two statements, one for density and one for melting point. Many candidates focused on the small change in value for the density rather than the lack of a trend in the melting point. Others wrote about how easy it would be to measure these values.

(e) Candidates rarely got both the name and structure of the ester correct. Some candidates reversed the ester by naming ethyl butanoate rather than butyl ethanoate. A common error was to miss out one of the oxygen atoms in the ester. Many candidates wrote the formulae of acids or alcohols rather than an ester. Another common error was to write the formula of butyl propanoate.

(f) Many candidates did not include the conditions needed for oxidation in their answer. Many referred to colour change unnecessarily. Most referred to potassium dichromate(VI) or potassium manganate(VII). Some candidates wrote that the dichromate(VI) or manganate(VII) was acidified. Others did not. The warm / high temperature / reflux condition was rarely present.

(g) Many candidates scored the mark for the products of incomplete combustion. Carbon dioxide was not permitted as a product of incomplete combustion.

Question B9

Many candidates confused rate and equilibrium aspects in this question. Equilibrium was often referred to in part **(a)** which was about rates of reaction and rates were often referred to in parts **(b)** and **(c)(ii)** which was about the effect of equilibrium. As in previous series, many candidates wrote confusing statements about the effect of temperature and pressure on equilibrium, sometimes giving conflicting statements. The calculation in part **(d)** was reasonably well done.

(a) (i) Candidates often confused rate of reaction and position of equilibrium and as a result gave answers that linked reaction rate to exo/endothermicity of reaction. Other candidates just referred to the number of collisions or collision frequency rather than focusing on the decreased speed or energy of the particles and the decreased number of successful collisions.

(ii) Candidates expressed the idea that the position of equilibrium moved to the left in a variety of ways often describing that the back reaction was favoured. The best answers referred to the back reaction being exothermic. In some cases the answers were confused: ideas about rate were introduced or suggestions that the equilibrium was shifted to the left because of the difference in number of moles of reactants and products.

(b) Candidates expressed that the equilibrium moved to the left in a variety of ways. Only the best answers linked this to the reactants having a smaller number of moles than the products. Many comments about rate rather than position of equilibrium were seen.

(c) (i) About half the candidates realised that the position of equilibrium is not affected by a catalyst. A common misconception was that there was an increase in the rate of reaction so that the position of equilibrium moved to the right. A considerable minority of the candidates did not answer the question and just stated the property of a catalyst in increasing reaction rate.

(ii) This was generally well answered. Many candidates not only referred to the lowering of the activation energy but also described the idea of an alternative pathway.

(d) Candidates often calculated the number of moles of carbon monoxide but did not always take the calculation any further. Others divided the enthalpy change by the number of moles. Some candidates did not attempt to calculate the amount in moles and used 560 and 210 to calculate an answer.

Question B10

Many candidates did not write in sufficient detail to gain marks in parts **(a)(ii)** and **(b)(i)**. Many candidates found it difficult to write an ionic equation for the anode reaction in the electrolysis of sodium chloride and even fewer could write an ionic equation for the reaction of silver nitrate with chloride ions. The calculation in part **(c)(ii)** was successfully attempted by many candidates, many of whom gained marks through error carried forward from the incorrect formula of silver chloride.

(a) (i) Many candidates knew the formula for a magnesium ion and an oxide ion. The most common error was to write MgO or, more rarely, to give incorrect charges.

(ii) Few candidates obtained the mark for explaining why magnesium oxide has a higher melting point than sodium chloride. Many candidates wrote insufficient or confusing statements about greater attraction or stronger bonding. Few mentioned ions, with some referring to intermolecular forces and covalent bonds. Only the best answers included reference to the stronger attraction between the ions in magnesium oxide

(b) (i) Many candidates misinterpreted the question and tried to explain why sodium chloride had a high melting point. Fewer candidates included all three points for each temperature i.e. statement of the temperature, the state of the compound (liquid or solid) and whether the ions could move or not.

The state was often omitted. Some candidates referred to the presence of electrons rather than ions. A significant minority of candidates did not refer to charged particles at all.

(ii) Common errors were: missing the charge on the chloride ion; putting $+2e^-$ on the left hand side; not balancing the equation (especially the chloride ions or electrons); writing the equation for a single atom of chlorine rather than for a chlorine molecule.

(c) (i) Few candidates wrote the ionic equation successfully. Common errors were: writing a 'molecular' equation; suggesting that the formula of silver chloride is $AgCl_2$; suggesting that silver chloride is an aqueous solution.

(ii) Many of the candidates could complete the calculation even if the equation in part **(i)** was incorrect or missing. Most candidates gained their marks through error carried forward from part **(i)** or from the wrong mass of silver chloride.

CHEMISTRY

Paper 5070/31

Practical Test

Key messages

It is suggested that teachers encourage candidates to read the questions more carefully in order to prevent the unnecessary loss of marks.

While quantitative techniques, such as titration, generally yield appropriate data, candidates would benefit from further practice in dealing with the use of such data in subsequent calculations.

In qualitative tests, candidates should be encouraged to mix reactants thoroughly and to record observations accurately, using suitable terminology.

General comments

The overall standard was again good. There were many candidates who proficiently executed the various tasks. Supervisors are thanked for supplying the experimental results needed to enable the assessment of candidates' results.

Comments on specific questions

Question 1

It was good to find in the calculations that there were candidates who were prepared to persist and so secure marks e.g. an incorrect answer in **(c)** was nevertheless processed successfully in **(d)** to score the mark.

(a) Many candidates were clearly competent in carrying out an acid-alkali titration and scored highly with their accurate titres. Nevertheless, there were a few centres where the necessary volumetric skills were insufficiently developed, as revealed by the wide range of titres recorded. There were some candidates who wasted time by doing unnecessary practical work e.g. by performing 5 titrations when 2 out of the first 3 titres were concordant. Two titrations were sufficient to obtain full marks providing the following requirements were met: the initial and final burette readings were given to 1 or 2 d.p.; there were two titres within 0.2 cm^3 of the Supervisor's value; and the average was correctly averaged using two or more results that did not differ by more than 0.2 cm^3.

Most of the candidates completed the table of results properly but there were some who did not tick any results or ticked only one and others who simply averaged all the titres regardless of their consistency.

(b) Many solutions showed the correct use of the molar ratio from the equation and provided answers for the number of moles of phosphoric acid in 1.00 dm^3 to 3 significant figures. The most common loss of one mark was due to insufficient precision in the final answer. Some candidates were unable to manage the calculation, and a few carelessly employed 20 cm^3 as the volume of **Q** despite using a 25 cm^3 pipette.

(c) The most frequent error was dividing the answer from **(b)** by 10 before multiplying by 98.

(d) Successful candidates either divided the answer from **(c)** by 100 and then by 1.03 or divided the answer from **(c)** by 103, before multiplying by 100. There were many who struggled with this part and since 1.03 was often smaller than the answer in **(c)**, it was not uncommon to find 1.03 as the numerator in the attempted calculation.

Question 2

It was rare to find that all the tests had not been attempted. All the scoring points listed in the mark scheme were awarded in the assessment of examination scripts. The most successful candidates carefully followed the instructions and recorded observations clearly using appropriate terminology. While others displayed competence at times, they were inconsistent in their approach. Consequently, marks were lost 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 naming a gas without giving the supporting test and observations.

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 marks for this question.

R was sulfuric acid.
S was copper(II) sulfate.

Test 1

Many candidates noted a white precipitate was formed in **(a)**. Descriptions such as liquid turns milky or cloudy on addition of barium nitrate gained no credit. A mark was given in **(b)** for any indication that the solid remained when nitric acid was added.

Test 2

The bubbling of the liquid caused by the addition of the carbonate to **R** was recorded by most candidates. Not all went on to test the gas but those who did generally turned limewater milky. Unfortunately despite recording the correct test, the gas was not always named.

As previously indicated simply stating carbon dioxide is produced without any evidence of its evolution or test for its identification scored no marks.

There was a mark available for reporting that the added solid disappeared but it was rarely noted.

Test 3

In **(a)** the zinc and the acid **R** produced little effervescence but once **S**, copper(II) sulfate, was added to the mixture the rate of bubbling increased. Once again the gas needed to be successfully tested before it could be identified as hydrogen. Despite the test and its result being available on the final page of the exam paper, there were a number of candidates who reported the test incorrectly. ‘Pops with a glowing splint’, ‘pops with a splint’ and ‘pops’ are not acceptable identifications of hydrogen. The gas (mixed with air) has to be ignited to produce a ‘pop’.

The appearance of a brown solid, copper, in **(b)** was reported by relatively few.

Test 4

There were a number of candidates who were able to record all six observation marks because they added the aqueous ammonia to excess and then **R** to excess, slowly and with thorough mixing. Some added both liquids too quickly and recorded the solution turned dark blue in **(a)** and then light blue in **(b)** for two marks. Others carried out the test in **(a)** well scoring three marks but then missed the reappearance of the precipitate in **(b)** and simply noted the solution turned light blue or sometimes and without credit, colourless. There were a few candidates who did not mix the solutions together and as a result scored little.

Test 5

Despite being an unusual test, there were many who successfully completed all the parts. In **(a)** **S** remains unchanged in appearance but the blue colour of the solution darkens when the alkali is added in **(b)**. The change in colour of the liquid on heating was seen by most and the more observant waited for the red/brown solid to settle out.

Test 6

In general candidates who had been successful in Test 1 performed well in this test but there were a few who believed the precipitate in **(a)** was blue.

Conclusions

Candidates who reported a white solid, which remained in nitric acid in both Tests 1 and 6, almost always identified the anion in **R** and **S** as sulfate.

On the basis of the blue colour of the solutions and/or the precipitates associated with **S**, the cation was reported to be copper but there a few who carelessly wrote copper was in **R**. While many recognised the production of gas from a carbonate and a metal meant **R** contained hydrogen ions, there were some who suggested a metal ion such as aluminium, zinc or calcium.

CHEMISTRY

Paper 5070/32

Practical Test

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On the basis of the blue colour of the solutions and/or the precipitates associated with **S**, the cation was reported to be copper but there a few who carelessly wrote copper was in **R**. While many recognised the production of gas from a carbonate and a metal meant **R** contained hydrogen ions, there were some who suggested a metal ion such as aluminium, zinc or calcium.

CHEMISTRY

Paper 5070/41

Alternative to Practical

Key Message

- There seems to be a certain amount of uncertainty by candidates when deciding how many significant figures/decimal places to include when giving a numerical answer. If there is doubt it is better to give too many significant figures than too few as candidates may not achieve the required marks if too few are quoted. The main reason for not achieving the available marks is if numerical answers are rounded incorrectly.

  It is also essential that candidates show all working out in calculations wherever possible.

- When describing the addition of nitric acid in the silver nitrate test for chlorides, some candidates said that nitric acid was added in order to 'kill' any carbonate present. Although this statement is not penalised, it is not the kind of terminology that should be used in chemistry.

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 accurately using the appropriate significant figures.

Comments on Specific Questions

Question 1

(a) This question concerns identification of laboratory apparatus and was well answered.

(b) Most candidates were able to give a test for carbon dioxide, although the result was not always included.

(c) Most candidates were able to read the volume on the gas syringe as 66 cm^3, although a small number recorded volumes as 60.3 cm^3 or 63 cm^3.

(d) The number of moles was generally correctly calculated.

(e) (i) Candidates generally used the mole ratio in the equation to multiply the answer to **(d)** by two.

(ii) Many candidates calculated the relative formula mass correctly, but the answer of 168 was also common. This was achieved by multiplying the correct answer of 84 by two, because of the figure two in the given equation. The value of 106, which is the relative formula mass of Na_2CO_3, was seen occasionally.

(iii) The mass was often correctly calculated.

Question 2

(a) The colour of bromine was usually known.

(b) (i) The movement of bromine vapour was recognised by the majority of candidates.

(ii) It was expected that candidates would realise that the bromine vapour would spread further and eventually fill both gas jars after a few minutes.

(iii) The word diffusion was known by some candidates. Because the bromine liquid turned into bromine vapour, evaporation was also accepted.

(c) (i) Candidates did not always show understanding of the terms branched and unbranched. Many candidates drew the same molecule in both parts, representing the same molecule as either structural or displayed formulae. In some cases a straight chain molecule was represented with a bend, which was intended to be representative of a branch.

(ii) Most candidates were aware that unsaturated molecules contained a C=C bond.

(d) (i) The decolourisation of bromine was known by large numbers of candidates.

(ii) Many candidates showed the organic product as having fewer than eight hydrogen atoms and /or fewer than two bromine atoms. Products other than an organic product were also common.

Question 3

It was not always appreciated that the production of ethanoic acid from ethanol is an oxidation, not a reduction reaction.

Question 4

It is the test for sulfur dioxide gas is that changes the colour of acidified potassium dichromate(VI) from orange to green.

Question 5

The R_f value is calculated by the distance travelled by **X** from the start line divided by the distance travelled by the solvent front from the start line.

Question 6

Correct calculation of the number of moles of carbon and hydrogen atoms, leads to the smallest whole number ratio of atoms of each element which gives the empirical formula.

Question 7

Calculation of the number of moles of Na_2SO_4, followed by use of the ratio in the given equation and evaluation of the correct volume and concentration, leads to the correct number of moles of sodium hydroxide required.

Question 8

(a) Candidates almost always calculated the correct mass.

(b) A small number of candidates knew the correct colour change at the end-point of the titration

(c) The majority of candidates completed the table and deduced the correct volume for use in the subsequent calculations.

(d) – **(k)** As usual, errors are carried forward so that candidates are given credit for correct chemistry even if an error has been made in an earlier part. It is essential to show full working out in all parts.

In **(k)** it was expected that candidates should realise that x must be a whole number.

(l) **(i)** A small number of candidates identified iron(III) sulfate. Sulfur was a common answer, due to the yellow colour.

(ii) A small number of candidates could deduce that atmospheric oxidation by oxygen had occurred.

(iii) The use of sodium hydroxide solution to identify cations was only applied here by a small number of candidates.

Question 9

This question involves the analysis of copper(II) chloride. The dissolving of the blue precipitate of copper (II) hydroxide in excess aqueous ammonia was known by only a small number of candidates. In this reaction it is essential to refer to the **deep** blue solution that forms when the precipitate dissolves.

The correct formula of **W** was often given.

Question 10

(a) Candidates often knew that the reaction was exothermic, although endothermic was sometimes seen.

(b) – (c) These parts scored very well. The majority of candidates were able to complete the table and draw the two straight lines required.

(d) **(i)** The majority of candidates were able to deduce the correct rise in temperature. The working out was almost always shown clearly on the graph.

(ii) This scored marks less frequently, largely because candidates had to add the initial temperature of $20.0^{o}C$ to the value deduced from the graph. Most candidates only read off the value from the graph.

(e) Only a small number commented on the fact that all the acid had reacted with (less than) 0.50g of magnesium (therefore addition of more magnesium would not produce a further temperature increase).

(f) **(i)** Many candidates read off the correct mass of magnesium from the graph.

(ii) Many candidates could divide their answer to **(f)(i)** by 24 to arrive at the correct number of moles.

(iii) Candidates were expected to use the mole ratio in the equation and their answer to **(f)(ii)** to deduce the number of moles of hydrochloric acid, and then use the volume of hydrochloric acid to deduce its concentration. This proved to be demanding.

CHEMISTRY

Paper 5070/42
Alternative to Practical

Key Messages

Graphical questions: when candidates are asked to draw a curve or a straight line through a set of points, the curve or straight line should be extended, where appropriate, to pass through zero; it should be noted that this is only required when the curve or straight line, on extension, would naturally pass though zero; a ruler should always be used to draw straight line.

Calculation questions: in answering calculations candidates should always show all of their working; most questions involve a one stage calculation and are worth one mark; when the number of marks allocated to a calculation is greater than one, it is an indication of its difficulty and in such cases one or more of the marks will be for the working; if no working is shown and the answer is incorrect all the allocated marks for that calculation are lost; candidates should always express their answers to a minimum of two significant figures except in titration questions where answers should be given to three significant figures.

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.

Candidates are encouraged to ensure their writing is clear, particularly in cases where unclear writing makes the chemistry ambiguous. For example in writing the formula for ethanoic acid it was sometimes difficult to differentiate between CH_3COOH and CH_5COOH. Care should be taken in the writing of formulae, numbers and chemical names.

Comments on specific questions

Question 1

(a) Iron(II) sulfate crystals are green. Any variation of green such as light or dark is acceptable but not mixed colours such as yellowy green etc.

(b), (c) The remainder of the question involves a series of calculations to determine the formula of iron(II) sulfate crystals. Any error may be carried forward to the next part and, if used correctly, gains the remainder of the marks.

Answers should always be given to at least two significant figures e.g. in part **(c)(iii)** a rounding down of the answer 0.011 to 0.01 was not acceptable.

(d) An accurate answer e.g. 6.82 must be shown somewhere in **(i)** before rounding to a whole number, 7, in **(ii)**.

Many candidates completed the question successfully gaining full marks, most others were able to get some or most of the marks.

Question 2

(a) Most candidates gave a correct structure for ethanol although several candidates omitted the bond between the O and H atoms.

Most candidates gave the correct name and formula for ethanoic acid.

Oxidising agents such as acidified potassium manganate(VII) or acidified potassium dichromate(VI) were common answers although marks were often lost by an incorrect oxidation state, poor naming or spelling or omission of an acid.

(b) Common errors included omission of a cork holding the thermometer in the top of the column and water flowing through the condenser in the wrong direction.

Fractionation or fractionating column are acceptable names for the apparatus **A**. Alternatives such as fractionalating or fractional column, were not acceptable.

In explaining its purpose the word separating or separation is important although answers strongly inferring this were awarded a mark.

(c) Many correct answers were seen. A common error was suggesting in **(iii)** that the all the propanoic acid has distilled over when temperature reaches 164^oC rather than when the temperature rises above 141^oC.

Questions 3

The correct formula for the ester is **(a)** $C_2H_5CO_2C_3H_7$.

Question 4

Option **(d)** is the correct answer. Chlorine is produced at the anode during electrolysis not the cathode as suggested.

Question 5

Option **(d)** indicates that the mass of manganese(IV) oxide, a catalyst, is unchanged during the reaction.

Question 6

Option **(b)** is the correction answer. The straight line XY shown on the graph indicates that no more hydrogen is being produced.

Question 7

Option **(c)** is the correct answer. Twice the volume of hydrogen is achieved by doubling the number of moles of acid added, taking into account that sulfuric acid is diprotic.

Question 8

Many candidates gained full marks on this question.

(a) Most completed this subtraction correctly.

(b) Most gave the correct colour change for the indicator from pink or red to yellow.

(c) As usual, when errors are made in reading the burette diagrams or in subtracting the volumes, the mean must be taken from the closest two titres. A common error is using titres 2 and 3 to calculate the mean irrespective of any of the aforementioned errors which may place two other titres closer.

(d) – **(j)** As usual, errors may be carried forward so that candidates may gain credit for correct chemistry even if an error has been made in an earlier part.

In **(j)** the relative formula mass of **R**CO_3 is calculated using answers to **(a)** and **(i)**. Whatever the answer, 60 should be subtracted to give the atomic mass of **R**.

(k) R is magnesium. The answer is based on the information in the question and that the formula for **R**CO_3 indicates that **R** has a valency of 2.

Aluminium, a common choice, is incorrect as its valency is 3.

Question 9

This question involves the analysis of zinc iodide.

The reactions were generally well known.

(a) A colourless solution is produced. Colourless compounds, solids, precipitates were not acceptable.

(b), (c) A number of ions were suggested but marks were awarded for Zn and A*l* ions in **(b)** and Zn ions in **(c)**.

Common errors included no mention of ions and incorrect ion charges.

(d) Most candidates gave a correct test for the iodide ion, however a few candidates confused the test with that of the sulfate ion.

When a candidate concluded that aluminium was present in **(c)** the formula for aluminium iodide was accepted in **(d)**.

Question 10

(a) Most candidates read the thermometer diagrams and completed the table of results correctly.

(b) Candidates are asked to plot the results on the grid and connect the points with two intersecting straight lines.

Candidates lost marks by joining the points at 0.6 and 0.8 with either a straight line or a curve.

Marks were also lost for incorrect plotting, not extending the line through zero and not drawing straight lines.

(c) Marks are given for candidates reading their own graphs correctly.

The reaction between zinc and copper(II) sulfate was generally correct.

Candidates use their own answer **(c)(iii)** to calculate the moles of zinc used in the reaction and then to calculate concentration of aqueous copper(II) sulfate.

As with **Question 1**, rounding up or down the answers before completing the second part is penalised.

(d) Most candidates gave two correct observations for the experiment.