CHEMISTRY

Paper 5070/11
Multiple Choice

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

General comments

Candidates found **Questions 8**, **9**, **15**, **22**, **29** and **36** to be relatively straightforward.

There was evidence of guessing in **Questions 13**, **14**, **20** and **23**. **Question 33** was found to be particularly challenging.

Comments on specific questions

Question 1

Candidates choosing option **D** did not link the accuracy of the measurement specified with the correct piece of apparatus.

Question 4

Option **C** was a common incorrect answer. These candidates identified ammonia as the gas in the test, but then incorrectly linked its formation to the presence of ammonium ions rather than nitrate ions.

Question 5

Candidates selecting option **D** did not appreciate that oxygen gas is not flammable.

Question 12

This question was correctly answered by most candidates. However, some candidates chose option **D**, the total number of atoms in one ‘unit’ of ammonium sulfate.

Question 13

This question required knowledge of several parts of the electrolysis syllabus and the ability to recognise the relevant half equation. There was evidence of guessing by some candidates.

Question 14

This question required knowledge of several parts of the electrolysis syllabus. The spread of responses suggested guessing some candidates, but some evidence that higher scoring candidates thought **A** was correct. Candidates who chose options **A**, **B** and **C** did not know the ratio of oxygen and hydrogen collected in Y and Z in the electrolysis of dilute aqueous sodium chloride.

Question 17

Option **B** was a common incorrect choice. These candidates did not link the knowledge in **11.3(d)** and **(e)** of the syllabus, ‘describe the formation of ethanol by the…fermentation of glucose’ and ‘state some uses of ethanol… as a renewable fuel’.

Question 20

There was some evidence of guessing with options **B** and **D** both being selected. Most candidates could identify reaction 1 as an oxidation but could not use the idea of electron gain/loss in reactions 2 and 3.

Question 23

Candidates selecting option **C** had overlooked the word ‘excess’ in the question.

Question 25

Option **B** was chosen more than the key, **A**. Candidates did not link the exothermic forward reaction of the Haber process to the effect of an increase in the reaction temperature.

Question 27

Most candidates worked out that option **D** was incorrect. There was then some evidence of guessing between the three remaining options. Candidates did not work out that element X is a metal in a period below element Y, a non-metal.

Question 28

Almost a third of candidates chose option **D**. They did not demonstrate knowledge of the correct trend in melting points in Group **I** or did not use the Periodic Table to locate rubidium and deduce its reactivity.

Question 32

Option **C** was a popular incorrect choice, with candidates selecting an equation with magnesium, but this shows the reduction of Mg^{2+}, the reverse of the key. There was also some evidence of guessing

Question 33

Over half of candidates selected options with aluminium as a 2+ ion.

Question 35

Candidates selecting option **A** thought that the substitution by chlorine in methane ends at chloromethane.

Question 38

Candidates choosing option **A** had overlooked the ‘C’ in the ‘COO’ part of the formula.

CHEMISTRY

Paper 5070/12
Multiple Choice

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

General comments

Candidates found Question **40** to be relatively straighforward.

Incorrect options were common on **Questions 1**, **4**, **25**, **28** and **35**. There was evidence of guessing in **Questions 12**, **21**, **28**, **30** and **35**. Question **40** was found to be particularly challenging.

Comments on specific questions

Question 1

There was some evidence of guessing by candidates. One possible explanation is that candidates had not done or seen this experiment.

Question 4

Option **A** was chosen more than the key. Candidates recognised that the tests specified would give those results with Al^{3+}, but not that they would also give the same results with Zn^{2+}. These candidates also missed the presence of and test for chloride ions.

Question 5

Candidates who chose option **D** did not appreciate that oxygen gas is not flammable.

Question 10

Option **D** was a common incorrect choice. These candidates mistook the greatest number of H atoms in the molecule rather than the highest percentage by mass of H atoms in the molecule.

Question 12

Option **A** was commonly selected, which correctly ignored the water formed, but did not take the unreacted oxygen into account. The stem did not state that the oxygen is in excess and this had to be deduced. There was also evidence of guessing by candidates.

Question 17

Candidates selecting option **B** did not link the knowledge in syllabus sections **11.3(d)** and **(e)**, 'describe the formation of ethanol by the…fermentation of glucose' and 'state some uses of ethanol… as a renewable fuel'.

Question 21

There was some evidence of guessing by candidates. This suggests that they don't have a good understanding of the effect of changing conditions on the position of the equilibrium in a reversible reaction.

Question 23

Option **A** was a common incorrect choice, with candidates not recognising that hydrochloric acid is a source of chloride ions. There was also some evidence of guessing by candidates.

Question 24

Option **D** was a common incorrect choice. These candidates chose a word linked to salt formation but did not link in the solubility of ammonium salts. There was also some evidence of guessing by candidates.

Question 25

Option **A** was a common incorrect choice. Most candidates knew the role of vanadium(IV) oxide in the contact process. However, a third of candidates thought water is a reagent rather than a solvent.

Question 28

This item about Group I metals, uses an element lower in the table than candidates are familiar with. Perhaps they did not use the Periodic Table to locate caesium and deduce its reactivity. There was some evidence of guessing by candidates.

Question 29

Candidates selecting option **D** did not recall that molten metals conduct electricity.

Question 30

There was some evidence of guessing by candidates. This suggests these candidates had poor knowledge of syllabus sections **9.2(a)(i)** and **(ii)**.

Question 32

Option **C** was a popular incorrect choice. Most candidates selected an equation with magnesium, but this shows the reduction of Mg^{2+}, the reverse of the key.

Question 35

Options **A** and **B** were chosen more than the key. There was evidence of guessing by candidates and a poor understanding of the substitution by chlorine in methane.

Question 37

Candidates selecting option **B** thought that alcohol molecules contain hydroxide ions.

CHEMISTRY

Paper 5070/21
Theory

Key messages

- Candidates need to show the working out in calculations by quoting the formula used, then substituting in the correct values and finally calculating the answer.
- Candidates must not use ideas about rate of reaction and collision theory when answering questions about chemical equilibrium. Candidates also used collision theory rather than kinetic particle theory when answering questions about the properties of gases.
- Candidates must use the correct terminology when answering free response questions on structure and bonding. It is important to distinguish between particles (atoms, ions and molecules) and attractive forces (metallic bonds, ionic bonds, covalent bond and intermolecular forces).

General comments

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

In ***Section B*** there were no unpopular questions. A significant proportion of the candidates did not follow the rubric on the question paper and attempted all four optional questions.

Comments on specific questions

Section A

Question 1

(a) (i) Most candidates could recognise the molecule with only 14 atoms.

(ii) Most candidates could recognise the structure of propanol that is oxidised to make propanoic acid.

(iii) Many candidates recognised the structure of methylpropane as an isomer of butane.

(iv) Many candidates recognised the structure of an alkene that can be hydrated to make an alcohol.

(v) Some candidates could recognise the compound made up of four elements.

(b) Some candidates recognised the two carboxylic acids, but others only identified one of the carboxylic acids. A small but significant proportion of the candidates left this question blank.

Question 2

(a) A significant proportion of the candidates appreciated that argon is the most abundant noble gas in the atmosphere. The most common incorrect answers were neon or helium.

(b) Many candidates referred to the use of helium in making balloons. A common misconception was that helium is used in hot air balloons.

(c) The idea that radon has a complete outer shell of electrons was well known. Some candidates referred to radon having eight valence electrons, which was given full credit.

(d) (i) Most candidates were able to give a similarity of the two isotopes. The most common answer referred to the same number of protons or the same atomic number.

(ii) Many candidates recognised that the isotopes differed in terms of the mass number, nucleon number or the neutron number.

(e) Candidates often gave a well worked out answer to get XeO_3F_2. The biggest error was not to calculate the percentage of xenon in the compound and to get an answer of O_3F_2. Other errors included inverting the expression for the amount in moles or not using the ratio of moles but using the ratio of the percentages.

(f) (i) A significant proportion of the candidates gave answers that were linked to rate of reaction rather than gas laws and referred to an increase in the frequency of successful collisions. Candidates often appreciated that the molecules move faster and are moving apart as the temperature increases but did not always link this with the volume of gas increasing.

(ii) Some candidates thought that the volume increases rather than decreases and others that the particles would change speed. The best answers explained that the particles were closer together and did not refer to the idea of collisions.

(iii) Candidates were often able to calculate the amount in moles from the volume and the molar gas volume. Although many of these candidates then multiplied by the molar mass, they did not always quote the answer to two significant figures.

Question 3

(a) (i) Many candidates recognised that the process was fractional distillation.

(ii) Candidates were often able to list another fraction separated from petroleum. The most popular fraction was bitumen with a use related to road surfaces or water proofing. Kerosene or paraffin was another popular choice of fraction. Centres should advise candidates that a use stated as ‘fuel’ should be qualified by the name of the vehicle that uses the fuel e.g. kerosene as aviation fuel.

(iii) A significant proportion of the candidates did not attempt this question. The candidates who did answer the question often recognised that the demand for short chain hydrocarbons was satisfied by cracking. These candidates often described the chemical changes that take place during cracking.

(b) (i) Candidates often gave a definition for non-biodegradable and referred to the polymer not decaying, not decomposing or not rotting.

(ii) Candidates gave a variety of environmental problems including litter, filling land-fill sites and plastic pollution in the sea killing animals. Candidates sometimes referred to the production of greenhouse gases, toxic gases or named carbon dioxide and carbon monoxide but these answers were not given credit unless it was clear they were formed as a result of incinerating plastic waste.

(iii) Candidates found this question quite challenging. Answers sometimes left out the free bonds at the end or included a double bond in the structure.

(iv) Candidates often ignored the information about the percentage yield being 100 per cent and gave answers about the loss of product so the mass made was less than 100 tonnes. Only the best answers appreciated that 100 tonnes of polymer is made since there are no co-products, as it is an addition reaction. A significant proportion of the candidates did not attempt the question.

(v) Those candidates that answered the question were often able to give the structure of chloroethane. Most of the answers showed all the atoms and all the bonds even though C_2H_5Cl would have sufficed.

Question 4

(a) Candidates often gave the physical properties of a transition metal rather than of an ionic compound and as a result gave properties such as hard, strong, dense etc. The best answers mentioned a high melting point and gave the solubility in water and/or the lack of solubility in non-polar solvents.

(b) Candidates often gave answers that referred to the properties of transition elements rather than compounds of transition elements. The best answers referred to copper(II) chloride being coloured.

(c) Only the best answers referred to copper atoms losing two electrons that were gained by a chlorine molecule. Most answers appreciated there was an electron transfer normally from copper to chlorine and that this involved two electrons being lost by copper. Centres should advise candidates to specify the particle involved in loss and gain of electrons so that the ideal answer would have been a copper atom loses two electrons, which are given to one chlorine molecule to make two chloride ions.

(d) (i) Candidates often recognised that oxidation involves losing electrons but did not specify that it was the iodide ion that was oxidised. Some candidates referred to oxidation numbers and they normally gave the correct change in oxidation number.

(ii) Candidates often appreciated that reduction involved the gain of electrons but sometimes they were inaccurate in terms of the particle that loses electrons and just referred to copper ions rather than copper(II) ions. Some candidates referred to oxidation numbers and they normally gave the correct change in oxidation number.

(e) Many candidates could only name one correct product. Common errors were the formation of copper, carbon monoxide or oxygen.

Question 5

(a) Many candidates were able to balance the equation. A significant proportion of the candidates used fractions to balance the equation.

(b) Acid rain was the most popular answer rather than an effect of acid rain. A very small proportion of candidates gave health issues rather than environmental issues.

(c) Many answers were quite confused and did not write the steps in order. A significant proportion of the candidates also described the formation of sulfur dioxide from sulfur, which was not required. Candidates often gave the conditions for the Contact process but did not link the conditions to the reaction between sulfur dioxide and oxygen to make sulfur trioxide. Candidates often gave three conditions for the reaction between sulfur dioxide and oxygen but at times, got one of them incorrect. Some candidates recalled that sulfur trioxide is reacted with concentrated sulfuric acid to make oleum and then this was reacted with water; others just reacted sulfur trioxide with water. Both approaches were given credit.

(b) The two most common answers were as a food preservative and as a bleach.

(e) (i) Candidates did not always describe the formation of carbon dioxide or that carbon reacts with carbon dioxide to make carbon monoxide.

(ii) Candidates often described that limestone reacts with sand to make slag, sometimes illustrating this with an equation. This was not given credit since it is calcium oxide that reacts with sand to make slag. Only a small proportion of the candidates described the decomposition of limestone to make calcium oxide.

(iii) Candidates often recognised that the hot air reacts with carbon to make carbon dioxide and also that it helps to keep the temperature within the blast furnace hot.

Section B

Question 6

This was the most popular question of the optional questions.

(a) (i) The most popular correct answer was methane.

(ii) Most candidates recognised that the increase in percentage of carbon dioxide would lead to climate change or global warming. A few candidates mentioned problems associated with global warming but almost invariably mentioned global warming by name.

(b) The majority of candidates gave diagrams which showed the shells as circles and used dots and crosses. Some candidates gave the correct structure; other candidates gave examples with single bonds or missed the lone pairs on oxygen atoms.

(c) Most candidates could construct the balanced equation.

(d) (i) Some candidates gave answers based upon rate of reaction. Many appreciated that the position of equilibrium shifts to the right. Candidates were often unable to explain why this happens with sufficient clarity. Since the concentration of CO_2(g) is equivalent to the pressure, answers were accepted where the number of moles of gas on the left is greater than on the right of the equation.

(ii) Some candidates gave answers based upon rate of reaction. Many appreciated that the position of equilibrium shifts to the left. Candidates must be careful to ensure that the direction of the exothermic reaction or endothermic reaction is clearly stated e.g. in this example the backward reaction is endothermic or the forward reaction is exothermic.

(e) (i) The idea that the term ‘weak’ means that there is only partial dissociation was well known by the candidates. Only a small proportion of the candidates referred to a solution having a high pH or having few hydrogen ions.

(ii) Candidates found this quite challenging and often used the incorrect formulae for the ions involved or gave ‘molecular’ equations instead.

Question 7

(a) Candidates were often able to calculate the correct volume. The best answers calculated the moles of NH_4NO_2 and then the volume of N_2.

(b) Candidates often missed out the idea that the particles are less crowded or that there are fewer particles per unit volume. Candidates generally referred to a decreased collision frequency. Only a small proportion of candidates neglected to state that the rate of reaction increases.

(c) Some candidates appreciated that ammonia was a product of the reaction, but candidates found getting the formula for calcium nitrite quite challenging and as a result could not balance the equation.

(d) (i) Some candidates recognised the brown solution as iodine, although ammonium iodide was a common incorrect answer.

(ii) Some candidates recognised that this was an example of an oxidation. Only a small proportion of the candidates gave the alternative answer of a redox reaction.

Question 8

(a) Many candidates gave the answer 5.

(b) The most common misconception was that there was a lattice of atoms rather than positive ions and that the metallic bond was an intermolecular force. Candidates were most likely to be awarded a mark for a description of the sea of electrons. Most candidates drew diagrams but did not label them with sufficient detail and as a result, it was not possible to identify with certainty the identity of the particles. Candidates often showed the positive ions far apart from one another rather than being closely packed.

(c) Candidates could often recall two typical properties of metals but neglected that the question stated that only properties of transition elements were required. The most common answers were high melting point and high density.

(d) Candidates did not always appreciate that only silver oxide and silver hydroxide are bases and sometimes gave silver carbonate instead. Candidates recognised that nitric acid was the required acid needed for the preparation.

(e) (i) Candidates were often able to write the ionic equation providing they gave the correct formula for silver ions. Some candidates gave Ag^{3+} as the formula for silver ions.

(ii) Candidates found this equation more challenging than **(i)**, but with the help of the names of the products a significant proportion of the candidates gave the correct equation.

(iii) The most common misconception was that there were no mobile electrons rather than there were no mobile ions.

(f) Candidates often mentioned the formation of a precipitate but did not always state it was yellow.

Question 9

(a) Many candidates appreciated that the ester contained a carbon-carbon double bond. Some candidates only mentioned a double bond, but this was not sufficient since it could have been a C=O bond.

(b) (i) Many candidates recalled that bromine is used to test for unsaturation.

(ii) The best answers stated that bromine changed from orange to colourless, but many candidates just stated that the bromine was decolourised and this was given full credit.

(c) (i) Many candidates recognised the structure of ethanoic acid.

(ii) Candidates often recalled that a catalyst lowers the activation energy. Most candidates then mentioned that the reaction went by an alternative pathway, with only a small proportion mentioning that the collisions were more successful.

(d) (i) Many candidates did not appreciate that all steps in the calculation had to be shown since credit was given for the working out and not the answers. A significant proportion of the candidates did not make it clear that 100 was the molar mass of the ester and that mass equals moles x molar mass. It was not sufficient just to multiply by 100 since it was not clear where the numbers came from. The best answers calculated the relative formula mass of the alcohol and then worked out the number of moles and finally showed the calculation of moles x molar mass.

(ii) Candidates often worked out the correct percentage yield.

CHEMISTRY

Paper 5070/22
Theory

Key messages

- Some candidates would benefit by improving their knowledge of specific chemical reactions and in constructing equations, especially ionic equations.
- Many candidates need more practice in writing with precision.
- Some candidates need more practice in interpreting the stem of a question.
- Calculations were generally well done.

General comments

Many candidates tackled this paper well, showing a good knowledge of inorganic and organic Chemistry. The standard of English was generally good. A significant number the questions were left unanswered by some candidates.

Some candidates need more practice in learning specific chemical reactions in the syllabus together with the conditions required. For example, in **Question 3(b)(vi)** a variety of gases other than hydrogen were suggested and in **Question 4(d)(ii)** the products of the thermal decomposition of zinc carbonate were not always well known. In **5(c)(i)**, the conditions for the Haber process were also not always well known and in **Question 5(e)(ii)** many candidates confused the conditions for the hydration of ethene with those for fermentation.

Many candidates need more practice in constructing chemical equations. For example, in **Question 3(b)(v)** many candidates made simple errors in constructing the simplest ionic equation for neutralisation. In **Question 6(d)(i)**, most candidates did not use the information given to deduce the correct formula for the salts formed. In **Question 7(d)**, many candidates did not deduce the formula of magnesium sulfamate from the charges on the ions. Other candidates need more practice in constructing ionic equations such as the one in **Question 8(e)**. A knowledge of the charges on common ions would help here.

Some candidates could improve their performance by writing with greater specificity. Some candidates need more practice in writing answers with the correct amount of detail and precision, using specific chemical terms. For example, in **Question 2(b)** many candidates wrote vaguely about 'in hospitals' or 'for breathing'. In **Question 2(c)(i)**, most candidates did not refer to the total number of electrons and in **Question 3(a)(iii)** many candidates wrote vague statements relating to the disposal of polymers. In **Questions 4(b)**, **4(c)(i)** and **4(c)(i)**, many confused the terms atoms and ions. In **Question 6(c)(iii)**, many candidates wrote vague statements relating to concentration rather than a greater number of successful collisions or more particles with energy greater than the activation energy. Many candidates did not give precise terms when describing the structure and bonding of metals in **Question 8(b)**. The particles present were described as 'particles', 'atoms' or even molecules and the negative particles were sometimes described as 'ions' rather than electrons.

Many candidates need more practice in interpreting the stem of a question. For example, in **Questions 2(e)(i)** and **2(e)(ii)** some candidates did not give their answers in terms of the kinetic particle theory as requested whilst in **Question 2(e)(iii)** many candidates did not heed the instruction to give their answer to two significant figures. In **Question 3(a)(i)**, some candidates named the polymer rather than giving the type of polymer and in **Question 3(b)(iii)** many ignored the information in the stem of the question that the yield was 100 per cent and wrote vague answers relating to 'material being lost' or 'not all the reactants are converted to products'. In **Question 5(b)(ii)**, some candidates did not note the instruction in the stem of the question that the products should be ethene and one other product. In **Question 7(b)**, a significant number of candidates did not label their diagrams despite the instruction to do so. Some candidates did not heed both command words ‘describe’ and ‘explain’ in **Question 9(c)(iii)** and described the effect on the position of equilibrium but did not explain this.

Some candidates would benefit from further revision of specific topic areas such as the chemistry of polymers (**Questions 3(a)** and **3(b)(i)(ii)(iii)**), redox reactions (**Questions 4(b)** and **4(c)(i)(ii)**), and aspects of environmental chemistry (**Questions 3(a)(c)**, **6(a)** and **6(b)(i)(ii)(iii)**).

Many candidates were able to undertake chemical calculations involving the use of moles and gas volumes, percentage yield and calculation of empirical formula.

Comments on specific questions

Section A

Question 1

Many candidates identified at least three of the substances correctly in **(a)**. Fewer identified the two compounds having a pH less than 7 in **(b)**.

(a) (i) Many candidates recognised the molecule with only 11 atoms. The commonest errors were to suggest either **G** or **H**.

(ii) A majority of the candidates recognised that ethanol is oxidised to make ethanoic acid. There was no consistent common error.

(iii) Some candidates recognised cyclobutane as an isomer of butene. The commonest error was to suggest **D**, which has five carbon atoms.

(iv) Many candidates recognised **D** and only a small proportion of candidates selected **B**. The commonest incorrect answers were either **C** or **G**, which both have COO groups.

(v) This was the best answered part of this question, with most candidates recognising compound **H**. The commonest incorrect answers were either **C** or **E**.

(b) Some candidates recognised the two carboxylic acids but others only chose one of the carboxylic acids. The commonest incorrect answers were **A** (ethanol) or **G** (an ester).

Question 2

Many candidates gave good answers to **(c)(ii)** and **(d)**. In **(a)**, many did not give an accurate enough value for the percentage of oxygen in the air whilst in **(b)** few knew a suitable use for oxygen. In **(c)(i)**, hardly any candidates explained why both isotopes have exactly the same chemical properties. In **(e)(i)** and **(e)(ii)**, a minority of the candidates were able to explain the changes in volume in terms of the kinetic particle theory.

(a) Many candidates did not give an accurate enough value for the percentage of oxygen in the air. A significant proportion of the candidates gave 20 per cent rather than 21 per cent. Others suggested 28 per cent or 29 per cent or gave the percentage of nitrogen rather than the percentage of oxygen.

(b) Many candidates gave vague answers. A variety of uses of oxygen were given with most correct answers focusing on breathing aids either for diving or in hospitals. Many candidates gave vague answers. Some just referred to breathing or respiration and did not qualify their answers. Other candidates gave a use for air rather than oxygen, for example ‘used to make sulfuric acid’.

(c) (i) Most candidates answered a different question than the one that was set and gave an answer to state a similarity between the two isotopes, for example ‘the same number of protons’. Some mentioned the same number of electrons in the outer shell. This was not sufficient because this is the answer expected from a question about the similarity of chemical properties within a group. Candidates did not link the electronic configuration with chemical properties and so did not mention that the isotopes had the same electronic configuration.

(ii) Many candidates recognised that the isotopes differed in terms of the mass number, nucleon number or the neutron number. The commonest error was to suggest that the proton number / atomic number was different.

(d) Most candidates gave a well worked out answer to get $SeOCl_2$. The most significant error was not to calculate the percentage of selenium in the compound and to get an answer of Cl_2O. Other errors included inverting the expression for the amount in moles or not using the ratio of moles but using the ratio of the percentages. A significant minority divided the percentages by the atomic number rather than the relative atomic mass. Others thought that they were balancing an equation in the last step and converted a ratio of 1Se: 1O: 2Cl to get a formula of Se_2O_2Cl.

(e) (i) A significant proportion of the candidates gave answers that were linked to rate of reaction rather than gas laws. Candidates often appreciated that the molecules move slower and are closer together as the temperature decreased but did not always link this with the volume of gas decreasing. Others just stated that the volume decreases without mentioning the kinetic particle theory.

(ii) Some candidates thought that the volume decreases rather than increases and others that the particles would change speed or hit the walls of the container with a greater force. The best answers explained that the particles were further apart from one another and did not refer to the idea of collisions.

(iii) A significant proportion of the candidates did not appreciate that oxygen is O_2 and so the number of moles needed to be multiplied by 32 rather than 16. Many candidates did not read the stem of the question carefully enough and did not give an answer to two significant figures.

Question 3

This was the least well answered question of ***Section A***. Many candidates gained credit in **(a)(iii)**, **(b)(i)** and **(b)(vi)**. Others did not recognise the addition reaction in **(a)(i)** and made simple errors in the construction of the monomer in **(a)(ii)**. Many candidates would benefit from greater revision of polymerisation (**(b)(iii)** and **(b)(iv)**) and the general equation for neutralisation (**(b)(v)**). A significant number of candidates did not respond to **(b)(ii)** and/or **(b)(v)** of this question.

(a) (i) A minority of the candidates identified the addition reaction. The commonest error was to name the polymer rather than give the type of reaction. The commonest incorrect reaction type was ‘substitution’. A significant number of candidates read on to the next two questions and gave the incorrect answer, ‘biodegradable’.

(ii) A minority of the candidates drew the correct monomer. Others just gave the structure without double bonds and in brackets or did not remove the continuation bonds of the polymer.

(iii) Many candidates could suggest a problem with the disposal of polymers by combustion. Many gave the name of a gas produced, for example, carbon dioxide or carbon monoxide. A significant minority gave imprecise answers related to climate change such as ‘causes flooding’ or gave vague answers such as ‘releases pollutants’.

(b) (i) Many candidates gave a correct definition for biodegradable and often referred to the polymer decaying, decomposing or rotting. The best answers also included the role of microorganisms in the process. The commonest errors related to ‘recycling’ or ‘reuse’.

(ii) The best candidates showed the polymer containing a $-C-CO_2-C-CO_2-$ chain. Common errors were either to not include the ester linkage or place a hydrogen atom between the -O- of the ester linkage and the next $CH(CH_3)$ group. A few candidates drew the structure correctly but missed out one or both continuation bonds. Others drew the ester linkage incorrectly as C=O.

(iii) Candidates often ignored the information about the percentage yield being 100 per cent and gave answers about the loss of product. The idea of the formation of a co-product alongside the polymer was poorly expressed. The best answers appreciated that water is formed alongside the polymer. Common incorrect answers included ‘evaporation’, ‘some of the product escaped’ or ‘loss of reactant by spillage’.

(iv) A minority of the candidates realised that the lactic acid has been oxidised. Common incorrect answers included 'reduced', 'decolourised' or neutralised'.

(v) The ionic equation for neutralisation was not well known. Many candidates did not include the charges or wrote a molecular equation or a part molecular and part ionic equation. Others wrote unbalanced ionic equations.

(vi) Many candidates recognised that hydrogen is formed when an acid reacts with magnesium. Others suggested, incorrectly, that carbon dioxide or carbon monoxide is formed. A considerable minority of the candidates suggested magnesium oxide (which is not a gas) or ammonia (despite the fact that there is no nitrogen in the reactants).

Question 4

Parts **(b)** and **(c)(i)** were generally well answered. A minority of the candidates were able to predict two physical properties of zinc bromide in **(a)** and explain the reduction in **(c)(ii)**. Few candidates were able to choose a suitable solution to provide aqueous carbonate ions in **(d)(i)** or to name both products of the thermal decomposition of zinc carbonate.

(a) Many candidates gave the physical properties of a transition metal rather than of an ionic compound and as a result gave properties such as hard, strong, dense or malleable. The best answers mentioned a high melting point and gave the solubility in water and/or non-polar solvents. A considerable number of candidates did not read the stem of the question carefully enough and gave chemical properties instead of physical properties.

(b) The best answers referred to zinc atoms losing two electrons and that these electrons were gained by a bromine molecule. Most answers appreciated there was an electron transfer normally from zinc to bromine and that this involved two electrons being lost by zinc. Candidates should be advised to specify precisely the particle involved in loss and gain of electrons. A considerable proportion of the candidates wrote, incorrectly, about zinc ions and bromide ions forming zinc bromide.

(c) (i) Some candidates recognised that magnesium was oxidised because it loses electrons. Some candidates referred to oxidation numbers and normally gave the correct change in oxidation number. The commonest errors were to refer to zinc ions or magnesium ions.

(ii) Some candidates appreciated that reduction involved the gain of electrons but sometimes they were inaccurate in terms of the particle that loses electrons and just referred to zinc rather than zinc ions. Other candidates referred to oxidation numbers and normally gave the correct change in oxidation number.

(d) (i) Many candidates could not name a soluble carbonate and the most common incorrect answer was calcium carbonate. Sodium hydrogencarbonate, lead carbonate or copper carbonate were other incorrect answers which were not infrequently seen.

(ii) Many candidates only named one product or gave two products one of which was incorrect. Common errors include the formation of zinc, carbon monoxide or oxygen. A minority of the candidates suggested that acids or carbonates are formed.

Question 5

This was the best answered question on the paper. Most candidates were able to describe petroleum fractionation in **(a)** and explain the general formula in **(b)(i)**. Some candidates answered **(b)(ii)**, **(c)**, **(d)** and **(e)** well. Others need more practice in learning the conditions of the Haber process and hydration of ethene. A significant number of candidates did not respond to **(b)(ii)** and/or **(c)** of this question.

(a) Most candidates were able to give a brief description of fractional distillation. There were only a few examples where candidates confused fractional distillation with cracking.

(b) (i) The best answers used the general formula of an alkane and then substituted $n = 11$ to show that the compound was an alkane. Most candidates gave the general formula for an alkane but did not really offer an explanation. The commonest errors were C_nH_{2n} or C_nH_{2n+1}.

(ii) Almost all the correct answers produced C_2H_4 and C_9H_{20} even though there were other equations that could have been constructed. The commonest errors were to include H_2 as a product or ignore the instruction in the stem of the question that one of the products must be ethene. This led to incorrect answers such as $C_6H_{14} + C_5H_{10}$.

(c) Some candidates appreciated the need for nitrogen to make ammonia but were less accurate when it came to giving the conditions. A common error was to give V_2O_5 as the catalyst. Candidates were expected to give actual values for the temperature and pressure rather than quote just high pressure and a moderate temperature. A considerable minority of the candidates forgot to mention that nitrogen is required for the Haber process.

(d) Many candidates mentioned hydrogen was a fuel either in the context of a fuel cell or for rocket fuel. Only a small proportion of the candidates mentioned making margarine. Common errors included 'making acids' or vague statements such as 'in labs'.

(e) (i) Some candidates identified the requirement of water for the hydration of ethene. The commonest incorrect answers referred to acids or alcohol.

(ii) Some candidates confused the hydration of ethene with fermentation and so gave conditions such as absence of oxygen or a low temperature. A significant proportion of the candidates could recall that phosphoric acid was used as a catalyst.

Section B

Question 6

This was the most popular of the optional questions. Most candidates gave good answers to **(a), (c)(i)** and **(d)(ii)**. Fewer could identify a compound used in flue-gas desulfurisation in **(b)** or draw a correct dot-and-cross diagram for nitrogen in **(c)(ii)**. Others gave answers which were too vague when trying to explain rates of reaction in **(c)(iii)**. Few candidates were able to write the balanced equation for the reaction of nitrogen dioxide with sodium hydroxide in **(d)(i)**. A significant number of candidates did not respond to **(b)** of this question.

(a) Most candidates suggested acid rain as an environmental problem. A small proportion of candidates gave health issues rather than environmental issues. Other common errors included 'greenhouse gas', 'damage to the ozone layer' or vague answers such 'harmful'

(b) Some candidates appreciated the use of calcium oxide or calcium carbonate. A common misconception was to confuse flue-gas desulfurisation with the Contact process and so gave answers such as 'oxygen' or 'sulfuric acid'. Many other candidates appeared to guess the answer as suggested by 'nitrogen', sodium' or 'potassium permanganate'.

(c) (i) Many candidates were able to construct the balanced equation. The commonest errors were either to write oxygen as 2O or not to balance the NO.

(ii) A majority of the candidates gave diagrams which showed the shells as circles and used dots and crosses. Although some candidates gave the correct structure, examples with a double bond and a quadruple bond were also seen.

(iii) Some candidates appreciated that the particles had more kinetic energy or moved faster. Others just referred to' nitrogen and oxygen having more energy', which was not sufficient since, firstly, the answer had to refer to particles and secondly, the essential word kinetic (energy) was missing. Sometimes candidates only referred to more collisions or a greater collision frequency and this was not sufficient. Only the best answers referred to more successful collisions or more particles having energy above the activation energy.

(d) (i) Few candidates gained full credit. Many candidates did not include the formation of $NaNO_2$ as one of the salts. Formulae involving sodium e.g. Na_2O or NaO_2, were often invented in an effort to write a balanced equation. Other common incorrect products included HNO_2, HNO_3 and/or NaOH.

(ii) The difference between a weak acid and a strong acid was well expressed by most candidates but a few referred to dissolving rather than dissociation. Other candidates gave answers that did not mention dissociation at all and just referred to the pH value of the solutions.

Question 7

Some candidates calculated the volume of nitrogen formed in **(a)** showing the relevant working. Others did not used the molar gas volume correctly. In **(b)**, some candidates drew clear diagrams with appropriate labels. Other did not respond to the instruction to label the diagram. Few candidates gave sufficiently full answers in **(c)** to gain full credit and in **(d)** only a minority of the candidates could give a fully correct equation. A significant number of candidates did not respond to **(b)** of this question.

(a) Some candidates were able to calculate the correct volume of nitrogen by first calculating the number of moles of $NaNO_2$ and then multiplying by the molar as volume. Common errors were to divide the concentration of $NaNO_2$ by 24 or to divide 0.15 by 20 and then multiply by the molar gas volume in cm^3 rather than dm^3.

(b) Some candidates drew a gas syringe to collect the gas. A variety of other incorrect reaction vessels were drawn. The fact that many diagrams were not labelled often led to candidates not gaining credit because the gas-collecting vessels were poorly drawn and without graduation marks. Most candidates who drew an inverted measuring cylinder connected it directly to the reaction vessel or did not show the gas being collected over water.

(c) Candidates often missed out the idea that the particles are more crowded or that there are more particles per unit volume. Candidates generally referred to an increased collision frequency. A considerable proportion of the candidates did not state that the rate of reaction increases. Others wrote, incorrectly, about the particles moving faster.

(d) Many candidates appreciated that carbon dioxide was a product of the reaction. Many others gave the incorrect formula for magnesium sulfamate (usually $MgNH_2SO_3$ or $MgNH_3SO_3$) and as a result could not balance the equation. Another common error was not to balance the sulfamic acid by putting a 2 in front.

Question 8

This was the least well answered of the ***Section B*** questions. Some candidates stated the correct number of electrons in **(a)(ii)** and gave two physical properties of lead that are characteristic of metals in **(c)**. Fewer candidates were able to describe metallic bonding fully in **(b)** or name a suitable combination of acid and base in **(d)**. Many candidates need more practice in constructing ionic equation (**(e)**) and in explaining why ionic solids cannot be electrolysed (**(f)**). A significant number of candidates did not respond to **(b)** and/or **(e)** of this question.

(a) (i) Many candidates gave the answer 11 rather than 6 and appeared to have tried to work out the electronic configuration instead of using the position of lead in the Periodic Table. Other common incorrect answers included electronic configurations such as 2,8 or 2,8,8.

(ii) Candidates were more likely to deduce the correct number of electrons in the outer shell than to deduce the number of occupied shells. The commonest error was to suggest eight electrons; a complete outer shell.

(b) The most common misconceptions were a lattice of atoms rather than positive ions and that the metallic bond was an intermolecular force. Candidates were most likely to be awarded credit for a description of the sea of electrons. Some candidates who did not write about delocalised electrons did not draw them between the ions but as a cloud around the whole structure. Most candidates drew diagrams but did not label them with sufficient detail and also tended to show the positive ions far apart from one another rather than being closely packed.

(c) Candidates could often recall two typical properties of metals; the most common being good electrical and thermal conductors. Malleable and ductile were two other popular physical properties given as answers. Some gave characteristics that were not true for all metals for example high density and hard.

(d) Few candidates appreciated that only lead oxide and lead hydroxide are bases and sometimes gave lead carbonate instead. Other candidates gave lead salts such as lead chloride or lead nitrate rather than a base. A significant number of candidates gave acids other than ethanoic acid; sulfuric acid or hydrochloric acid being the commonest incorrect answers.

(e) A minority of the candidates were able to write an ionic equation with the correct state symbols. Many used the incorrect formulae for the ions such as Pb^{2-} or I_2^-. Others gave molecular equations instead. State symbols were normally correct but could only be credited if the formulae themselves were correct. A significant minority gave the correct equation but did not respond to the request in the stem of the question to include the state symbols.

(f) The most common misconception was that there were no mobile electrons rather than the ions were not mobile. Other common incorrect answers included 'there is not space for the particles to pass' or 'because a solid does not conduct electricity'.

Question 9

Many candidates identified the ester group in **(a)** and a majority of the candidates named the alcohol in **(c)(i)** correctly. Many were able to calculate the percentage purity in **(d)(ii)** correctly. Fewer candidates explained why ethyl propenoate turns aqueous bromine colourless in **(b)** or gained credit for the equilibrium questions in **part (c)(ii)** and **(c)(iii)**. In **part (d)(i)**, many candidates did not appreciate that all steps in the calculation had to be shown. A significant number of candidates did not respond to **parts (d)(i)** and/or **(d)(ii)** of this question.

(a) Many candidates identified the ester group correctly. Others included extra atoms that are not part of the ester linkage, the commonest error being to include both the carbon and hydrogen atoms to the left of the COO group. A few candidates just circled the oxygen atoms and did not include the carbon.

(b) Some candidates appreciated that the ester was unsaturated and/or contained a carbon-carbon double bond. Others only mentioned a double bond, but this was not sufficient since it could have been a C=O bond. Other common errors involved giving answers which were too vague such as 'it is an alkene' or 'the bromine reacts with it'.

(c) (i) A majority of the candidates recognised the structure of ethanol. The commonest error was to suggest 'propanol'.

(ii) Some candidates appreciated that the catalyst has no effect on the position of equilibrium. Others just defined a catalyst and did not address the question set. Many candidates suggested, incorrectly, that there would be a shift to the right.

(iii) A significant number of candidates gave answers based upon rate of reaction. Others appreciated that the position of equilibrium shifts to the right. Candidates were often unable to explain why this happens (in terms of reducing the concentration of added ethanol) with sufficient clarity to be awarded credit. A common vague explanation, which was not accepted, was (goes to the right) 'because more product is made'.

(d) (i) Many candidates did not appreciate that all steps in the calculation had to be shown since credit was awarded for the working out and not the answers. A significant proportion of the candidates did not make it clear that 100 was the relative formula mass and that mass equals moles × relative formula mass. It was not sufficient just to write 0.15×100 since it was not clear where these numbers came from.

(ii) Many candidates were able to calculate the percentage purity correctly. The commonest error was 58 percent, obtained by $100 \times 15/(10.8 + 15)$.

CHEMISTRY

Paper 5070/31
Practical Test

There were too few candidates for a meaningful report to be produced.

CHEMISTRY

Paper 5070/32
Practical Test

Key messages

- Success in this paper required a candidate to meet the practical and mathematical demands of a volumetric exercise.
- The examination's qualitative tasks generally involved test-tube observations. Candidates competent in following instructions involving test-tube reactions and in the accurate recording of their observations, performed well.

General comments

Candidates capably carried out the titration involved in **Question 1** and many successfully used the data generated in answering the related calculations.

While all the candidates attempted the tests in **Question 2**, there was variation in the standard and completeness of the observations recorded.

The number of scripts received in this series was extremely small and therefore a narrower range of different responses was seen than normal.

Comments on specific questions

Question 1

(a) The results table was almost always completed properly, and while the majority of candidates produced concordant titres, there was some variation in their accuracy. Once two concordant titres are obtained, there is no benefit to be gained from performing additional titrations.

Most candidates attempted all the calculations that followed, and many performed well.

(b) This did not require the processing of titration data so there was only one correct answer, which was calculated correctly by most.

(c) The majority divided their answer to **(b)** by two correctly, although some did not realise they needed to apply the stoichiometry shown by the equation.

(d) Many candidates used their answer from **(c)** and the average titre to calculate correctly the concentration of **P**. Nearly all candidates answered to three significant figures.

(e) This was often correctly tackled. Even if the concentration of malic acid was incorrectly calculated, most candidates were able to gain credit for the correct M_r of the acid.

(f) This was answered correctly by only a minority of candidates. There was some confusion about the conversion between dm^3 and cm^3, and a great deal of unnecessary or contradictory working was seen.

(g) This was poorly answered and almost always did not gain credit. Many candidates drew their own malic acid titration results into their answer, or just said that some apple juices have a higher concentration of malic acid.

Question 2

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

Candidates should be encouraged to make full use of the Qualitative Analysis Notes supplied.

(a) (i) **Test 1** This was generally well answered, although some did not mention the green solution formed in excess NaOH.

Test 2 Many candidates gained full credit here.

Test 3 This was less successfully answered. Candidates were often confused by the colour of the chromium(III) ions in the solution. It is important to allow the precipitate to settle in case of uncertainty.

(ii) This was well answered by those candidates who had made correct observations in **Tests 1** and **2** although iron(II) and aluminium were often incorrectly given.

(iii) This was well answered by those candidates who had made correct observations in **Test 3**, although the halide and sulfate tests were sometimes confused.

(b) (i) **Test 1** The addition of the aqueous sodium hydroxide to the solution needed to be done gradually with mixing. Those who were careful in their addition of alkali reported a green precipitate, which was insoluble in excess. A few candidates described the precipitate as grey or even black.

Test 2 There was a wide range of marks seen, with only the most thorough candidates securing full credit. Some candidates only noted the bubbling and did not mention the colour change. Others noted the bubbles but did not correctly identify, or sometimes even seek to identify, the gas.

Test 3 The same comments made for **Test 1** apply here too. The formation of a brown precipitate, which was insoluble in excess NaOH was widely described.

Test 4 This was less successfully answered. Candidates were again confused by the colour of the cations in the solution, this time iron(II).

(ii) Those who observed the green precipitate formed in **Test 1** usually identified iron(II) as being present in **S**.

(iii) Those who observed the brown precipitate formed in **Test 3** identified iron(III) as being present after the oxidation of the iron(II) ions in **S** during **Test 2**.

(iv) Those who observed the white precipitate formed in **Test 4** identified usually identified sulfate.

CHEMISTRY

Paper 5070/41
Alternative to Practical

Key messages

- It is important that candidates read the questions thoroughly to fully understand the practical context in which the questions are set and to answer questions in relation to this context.

General comments

Overall candidates answered questions well.

Comments on specific questions

Question 1

(a)(i)(ii) Most candidates were able to identify the apparatus.

(b)(c) It is important that candidates understand the term ‘observations’. This question required candidates to use terms such as ‘effervescence’ rather than simply stating that a gas was produced. A description of colours and states are also required, not just a repeat of the names of chemicals given in the question.

Question 2

(a) Most candidates were able to read and record the highest temperatures. A few candidates did not understand how to calculate a temperature change.

(b) A significant number of candidates referred to aspects of plotting a graph rather than to the practical need to repeat the experiment. A graph allows candidates to identify points which may be anomalous but practically repeating the experiment and comparing values checks whether the value is anomalous.

(c) Most candidates could plot the points accurately.

(d) Many candidates were able to draw appropriate lines. Some candidates incorrectly tried to draw lines that did not ignore the anomalous point. A few candidates did not extend the line to the point of intersection or tried to draw a curve instead.

(e) to **(g)**
Most candidates were able to read values correctly from their graphs.

(h) Most candidates recognised the need for some form of insulation. A few candidates were confused about what was happening in the experiment as they referred to Bunsen burners.

Question 3

(a) to **(d)**
This question was generally well answered, showing that many candidates are familiar with the qualitative tests. Some candidates reversed the tests for a sulfate and a halide.

Question 4

This longer question required candidates to carefully read the description given and respond appropriately. It was not expected that candidates were familiar with this specific experiment but tested their ability to apply general principles in a new context. A good number of candidates were able to answer this completely and obtain full credit.

Some candidates did not address all of the bullet points in the question where it tells them what to include.

A few candidates did not understand the context of the question or did not use the data that was provided.

A significant number of candidates described an investigation into the effect of concentration on rate. This was unnecessary but was not penalised as long as they addressed all of the bullet points in the question and compared at least one experiment with, and one without, the catalyst.

Question 5

(a)(i)(ii) Most candidates completed this correctly, although some made errors in calculating the change in mass.

(b) A significant number of candidates did not understand the difference between repeating in order to obtain an average and heating to constant mass.

(c) (i) Most candidates recognised that the change in mass was related to gas production, but many did not relate this to the fact that the gas escapes.

(ii) to **(v)**
Candidates generally had a good appreciation of mole calculations.

(vi) Please note that due to an issue with **Question 5(c)(vi)**, full marks have been awarded to all candidates for this question to make sure that no candidates were disadvantaged.

(d) (i) Most candidates could recognise a gas syringe but a wide variety of other pieces of apparatus were suggested as well.

(ii) Most candidates could measure the volume of gas shown in the diagram.

(iii) A number of candidates did not know how to calculate moles of a gas. Some tried to reuse the value of 44 in the calculation.

(iv) A number of candidates did not appreciate that gas would escape as the apparatus was connected and very few identified that the balance to measure mass has a much greater resolution than a gas syringe.

(v) Although many candidates suggested a precaution, few were able to link this to the fact that an acid is corrosive.

Question 6

(a) to **(d)**
This was a familiar context to most candidates and those who understood how to do mole calculations performed well.

A significant number of candidates did not recognise the importance of giving the appropriate number of decimal places when recording results. In particular, it was common to see a value of 0 rather than 0.0 in the table.

CHEMISTRY

Paper 5070/42
Alternative to Practical

Key messages

- In analysis questions, such as **Question 2(a)(i)**, symbols for ions (with charges) should be given as opposed to names.
- Candidates should thoroughly revise the tests for the ions and gases that are listed on the syllabus.

Question 1

(a) (i) This was usually answered well. Many candidates stated that a crucible is more heat resistant, or a glass beaker will crack if heated strongly. There was some confusion concerning whether glass was a good insulator or not.

(ii) Many candidates found this challenging. Most answers mentioned either accuracy or finding an average. Only a few mentioned the requirement to ensure that **all** the water of crystallisation had to be removed.

(b) (i) Almost all the candidates completed the table correctly.

(ii) Most candidates were able to plot the points correctly.

(iii) Most candidates encircled the anomalous point**.** Those who encircled all the points on the graph should have found a way of distinguishing the anomalous point from the rest.

(iv) Most candidates found this challenging. The final mass of $MgSO_4$ should have been less than 0.83 g. This suggests that the reason for the anomaly was that the salt had not lost all of its water of crystallisation. Reasons for this include that heating had not been carried out for long enough.

(v) The line of best fit was drawn correctly by the vast majority of candidates.

(c) (i) The vast majority of candidates were able to determine the mass of water lost correctly. A small but significant number achieved an answer of 1.14 by reading the graph at 1.20 g of water lost.

(ii) This was answered well by the vast majority of candidates. The relative molecular mass of water was occasionally calculated incorrectly.

(iii) Candidates found this question challenging. There were no common errors.

Question 2

(a) (i) Candidates found this question challenging. Fe^{2+} was seen as a common alternative.

Zn^{2+} and Al^{3+} were frequently seen as alternatives to Ca^{2+}.

(ii) Many candidates were well prepared for this type of question. Some candidates added another reagent as well as aluminium or aqueous sodium hydroxide.

Some candidates occasionally gave a completely different test.

(b) Several excellent answers were seen.

Candidates should make it clear whether they are carrying out tests on aqueous solutions or on gaseous products of reactions.

Tests for ammonium ions sometimes used aluminium as well as, or instead of, aqueous sodium hydroxide. This showed confusion with the test for nitrate ions.

The test for sulphite ions was less well known than the test for sulfate ions.

Tests for sulfate and sulphite ions were occasionally the wrong way round.

Question 3

(a) The vast majority of candidates knew that a burette or a pipette would result in a more accurate measurement than a measuring cylinder.

(b) Adding dilute hydrochloric acid to a burette and filling to the zero mark proved challenging for the majority of candidates.

Many gave beaker for **B** instead of the solution in the beaker as requested. A common error was to fill the burette with aqueous sodium hydroxide.

Only a small number of candidates mentioned reading the burette or filling it to the zero mark before starting the titration.

(c) Only approximately half of the candidates knew that an indicator had to be added to the flask before starting the titration.

(d) A colour change at the end-point was mentioned by the majority of candidates. This applied even if an indicator was not mentioned in **(c)**.

(e) (i) The need for purity, mentioned in the second part of the stem, explains why the experiment is carried out without the indicator.

The most common answer was 'because the volume of **B** was already known'.

(ii) Preparation of pure crystals from an aqueous solution was described well by the majority of candidates.

Question 4

(a) This was answered reasonably well by most candidates.

P was sometimes named as a fractionating column. **Q** was sometimes named as a volumetric flask, despite the lack of graduation. **R** was sometimes named as a separating funnel.

(b) (i) The vast majority of candidates gave pipette as the correct answer. The volume of $25.0\,cm^3$ as opposed to $25\,cm^3$ indicated that something more accurate than a measuring cylinder was required.

(ii) Candidates found this challenging and very few mentioned that the oxidising agent had to be acidified.

The oxidation number of potassium manganate was sometimes missing.

(iii) A colour change of purple to colourless was quite commonly known, even amongst those who gave an oxidising agent other than potassium manganate(VII). The colours were occasionally reversed.

(iv) Only a small number of candidates seemed familiar with the purpose of heating under reflux. The importance of the condensed liquid returning to the flask was only mentioned occasionally.

(c) (i) Only a small number of candidates gave ethanoic acid as the answer. Non-organic products were often given.

(ii) Fractional distillation was often correct.

(iii) The physical property of boiling point was mentioned frequently. However, many candidates suggested that the boiling points should be close together as opposed to different.

Different densities were mentioned occasionally.

Question 5

(a) (i) This was answered very well. A small number of candidates gave pipette as the answer.

(ii) This was answered quite well.

The description of the splint used was described as 'light', 'lighted', 'lighter', 'lightening' or 'lightened' to name but a few alternatives. 'Burning' may be a better choice for those who have issues with lighting.

(b) Many candidates suggested correctly that the hydrogen gas would escape.

Some tried to explain that it would be difficult to replace the bung and start the timer simultaneously. Such explanations need to be clear.

(c) (i) Many candidates found this challenging.

If time and volume were given, units were usually missing. Time and volume were often on the wrong axes. Many alternatives were seen. 'Mass / g', was the most common.

(ii) Candidates found this question extremely challenging.

Answers often seemed to be comparing graph **A** with the other three graphs. Some suggested that the rate of reaction increased before it decreased.

(iii) Many candidates had magnesium as the most reactive metal. There were no common alternative errors.

(iv) The volume and the concentration of the acid and the temperature were often seen as correct answers. Particle size/surface area of the solid was mentioned less often.

Changing the pressure only increases the rate of reaction between reacting gases.

The mass of metals had to vary from one metal to another in order to keep the number of moles of each metal the same.

(v) Candidates found this extremely challenging. Only a small number realised that different masses were used in order to keep the number of moles of each metal constant.