CHEMISTRY

Paper 5070/11
Multiple Choice

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

General comments

The paper consisted of 40 questions, which involved choosing the correct answer from four alternatives. Candidates found the following questions to be the least challenging: **Questions 1**, **5**, **8**, **32, 33, 34** and **37**. Questions which candidates found more challenging are analysed in further detail.

Comments on specific questions

Question 7

Many candidates chose option **B**. They correctly identified strong forces, but thought that magnesium oxide was a molecular compound.

Question 9

Option **B** was a common incorrect response. Candidates incorrectly linked cations in metals with conduction of electricity.

Question 10

Many candidates chose option **B**. They did not recognise that gaseous chlorine is a diatomic molecule.

Question 11

Options **A** or **B** were popular incorrect choices. This meant candidates either equated mol with dm^3 or they multiplied 24 dm^3 by 0.1 mol.

Question 13

Many candidates chose option **B**. They correctly identified the cathode, but chose insoluble $AgCl$ as an electrolyte.

Question 14

Many candidates chose option **B**. They correctly linked the idea of endothermic reactions with energy absorption, but thought this leads to a temperature rise.

Question 17

Many candidates knew that adding more water would form more precipitate. Very few candidates linked the addition of sodium hydroxide with the neutralisation of hydrochloric acid and, therefore, more precipitate being formed.

Question 19

Many candidates chose option **B**. They did not appreciate that oxidising agents are themselves reduced during a reaction.

Question 21

Many candidates did not have the required knowledge of salt preparation and solubilities to answer this question successfully.

Question 24

Many candidates chose option **C**. They did not appreciate the difference between numbers of *electrons* and *electron shells*.

Question 27

Many candidates did not appreciate that bonding and structure in alloys is similar to that of the metals from which they are formed.

Question 28

Many candidates chose option **B**. They did not appreciate the significance of the word 'solid' in statement 1.

Question 36

Option **D** was a common incorrect choice. Candidates choosing this option did not link the conversion of vegetable oil to margarine with a decrease in the number of carbon-carbon double bonds.

CHEMISTRY

Paper 5070/12
Multiple Choice

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

General comments

The paper consisted of 40 questions, which involved choosing the correct answer from four alternatives. Candidates found the following questions to be the least challenging: **Questions 2**, **5**, **23**, **31**, **32** and **33**. Questions which candidates found more challenging are analysed in further detail.

Comments on specific questions

Question 1

Many candidates chose **D**. **I**t is possible these candidates thought that the supply of air would be limited. Many candidates chose options with apparatus 1. This shows they did not appreciate the loss in mass due to the powdery nature of the product.

Question 7

Candidates favoured the incorrect responses **C** and **D**. They did not work out the valency of the metal ion from the information given.

Question 8

The majority of candidates could not link together the structure and bonding in carbon with the properties of its oxide.

Question 9

Many candidates chose option **B**. They correctly linked the idea of malleability to sliding, but to electrons rather than the metal ions.

Question 14

Many candidates chose option **B**. They correctly linked the idea of endothermic reactions with energy absorption, but thought this leads to a temperature rise.

Question 17

The correct answer was given by over half of candidates. However, a significant number of candidates chose **D**. They did not appreciate that ammonium chloride is an ionic compound.

Question 18

Candidates found it difficult to understand the effect of varying conditions on a reaction in equilibrium.

Question 19

Many candidates chose option **C**. They did not recognise the change in oxidation states of magnesium and hydrogen in the reaction.

Question 20

Candidates found this question difficult as it required knowledge from two different parts of the syllabus.

Question 25

Many candidates chose option **D**. They identified the correct trend in reactivity in Group **I**, but not the correct trend in melting point.

Question 27

Many candidates did not appreciate that bonding and structure in alloys is similar to that of the metals from which they are formed.

Question 35

Option **D** was the favoured incorrect response. They chose the option with the greatest formula mass rather than working out the empirical formulae and then selecting which of these had the greatest formula mass.

Question 36

Many candidates chose option **D**. They did not link the conversion of vegetable oil to margarine with a decrease in the number of carbon-carbon double bonds.

Question 40

Many candidates chose option **D**. They could not recall the types of linkages present in large molecules such as the protein and *Terylene* molecules.

CHEMISTRY

Paper 5070/21
Theory

Key messages

- Candidates need to show all relevant working out when completing calculations so that credit for an error carried forward can be awarded.
- Candidates must ensure they use collision theory when answering questions on rate of reaction and make certain they can distinguish between the effect of increasing concentration and temperature on the particles in a solution.
- Candidates often struggled when balancing equations because they used incorrect formulae. Candidates must recognise which elements have diatomic molecules and which elements it is appropriate to use the atomic symbol in an equation.

General comments

Candidates appeared to have sufficient time to complete all the examination paper.

Candidates found the optional questions much more demanding than the compulsory questions. There was some evidence that some candidates found it difficult to choose which three questions to answer.

Question 7 was the least popular of the optional questions.

Comments on specific questions

Section A

Question 1

Most candidates gave the letter rather than either the name of the atom or the electronic configuration.

(a) (i) Most candidates identified **C** as sodium.

(ii) Most candidates recognised **D** as a reactive non-metal, although some candidates gave **B** and **C** as reactive metals. Candidates found this more challenging than the other questions in **(a)**.

(iii) Most candidates recognised **B** as an atom with a proton number of 12.

(iv) Most candidates recognised **A** as a noble gas used in balloons.

(v) Most candidates recognised **D** as the atom that gains two electrons to get a stable electronic configuration.

(b) (i) Many candidates could deduce the number of neutrons as 20; a small proportion of the candidates just gave the full symbol for an isotope.

(ii) Candidates often struggled to give a precise meaning of the term *diatomic*. A common misconception was to refer to an element with two atoms. Another misconception was that it was two molecules. The best answers referred to two atoms bonded together to form a molecule.

Question 2

This question focused on the chemistry of zinc and nickel.

(a) (i) Many candidates found this question challenging and gave answers that referred to the gain and loss of oxygen. Other candidates recognised that zinc was oxidised by reference to either the increase in the oxidation state or the loss of electrons. The reduction process was often explained in terms of either nickel or nickel nitrate rather than the nickel ion. A small proportion of candidates just gave a definition for redox in terms of electron loss and gain. Others just mentioned that reduction and oxidation took place and made no attempt to relate this to the actual reaction.

(ii) A large variety of ionic equations were given and often these equations only involved the zinc ion. Many candidates included the nitrate ion in their equation. A small proportion of the candidates gave the incorrect formulae for the ions. Some candidates did not attempt this question.

(b) Candidates found this question quite challenging and a small proportion did not attempt the question. Some candidates gave a diagram that was recognisable as an electrolytic process; the labels were often incorrect. Most candidates did not know the name of a possible electrolyte and often gave insoluble or molten silver salts. The electrodes were either not identified or identified the wrong way around. The correct symbol for the battery or a cell was well known but its correct polarity was not. Candidates should be advised to label the electrodes with the words anode and cathode to avoid any confusion. Some candidates just drew the nickel fork and surrounded it with silver ions and avoided mentioning any electrolytic process.

(c) The most common misconception was to describe the changes in the electrolysis in **(b)**. Candidates were often unsure about the colour of the precipitate formed or whether in fact a precipitate was formed. The idea that the precipitate dissolves in excess ammonia to give a colourless solution was poorly expressed by many candidates.

(d) Some candidates confused this type of sacrificial protection with the idea of a barrier protection and galvanisation. The idea that zinc was more reactive than iron was often well expressed but sometimes the answer then mentioned the formation of a layer of zinc oxide. A significant proportion of the candidates mentioned zinc rusting rather than corroding.

Question 3

This question focused on tartaric acid and succinic acid.

(a) Many candidates recognised the hydroxyl group. Some candidates referred to hydroxide or gave the answer as –OH and these were not accepted.

(b) The colour change was not well known. A significant proportion of the candidates gave the colours for either acidified potassium dichromate(VI) or the colours for acidified potassium manganate(VII).

(c) Many candidates appreciated that a weak acid only partially dissociates but they often did not include the presence of the hydrogen ion. It is important that all aspects of the definition are addressed in the answer; in this case both weak and acid.

(d) Many candidates gave the answer to three significant figures. The best answers showed the amount in moles of succinic acid and of sodium hydroxide before calculating the volume. Some candidates could not convert the volume in dm^3 to cm^3 and others forgot to give the correct units when giving an answer of 0.125. Some candidates tried to use the equation

$\frac{M_1V_1}{n_1} = \frac{M_2V_2}{n_2}$ but often used the incorrect stoichiometry or mixed up the concentrations and volumes.

Question 4

This question was about the homologous series of alkanes.

(a) (i) Many candidates gave the general formula for the homologous series of alkanes.

(ii) Some candidates mentioned the same general formula even though this was given in the stem of the question. A significant proportion of the candidates referred to the same chemical properties rather than similar chemical properties. The idea of the same functional group was mentioned in many answers. Other candidates gave an example of a trend in a physical property typically the boiling point increasing as the number of carbon atoms per molecule increases.

(b) Candidates found it challenging to define the term *saturated*. Many answers referred to the presence of a carbon-carbon single bond; most of these did not state that these were the only type of carbon-carbon bonds present in the molecule. Some candidates gave definitions relating to a saturated solution rather than in terms of organic chemistry.

(c) Candidates were often able to balance the equation providing they appreciated that there was a reaction with oxygen to give carbon dioxide and water. Some candidates gave hydrocarbon products in addition to the correct combustion products.

(d) Candidates often struggled to draw a branched chain alkane and many answers were straight chains made to look like a branched chain.

(e) (i) Candidates often recognised that the reaction was an example of substitution. Chlorination and photochemical were also correct answers given by candidates.

(ii) A significant proportion of the candidates could recall that the reaction required sunlight or ultra-violet light. Some candidates did not attempt to answer the question or made some reference to high temperature.

(f) (i) The most common misconception was not to calculate the percentage of hydrogen in the hydrocarbon and so do the calculation with only the data for carbon. Other candidates used the same percentage for hydrogen as for carbon or inverted the expression for the amount in moles. Candidates often could not deduce the empirical formula from the correct mole ratio and rounded to give answers including CH and $C_{10}H_{13}$.

(ii) Some candidates understood the need for the relative molecular mass; others thought they needed the percentage of hydrogen in the compound, presumably because they had not appreciated how to calculate this piece of information in **(i)**. Other incorrect answers included the general formula, relative atomic masses and the molecular formula.

Question 5

This question was on the Periodic Table.

(a) The best answers related group number to the number of valence electrons and the period number to the number of electron shells. Some candidates described how the proton number changed across a period or how the number of valence electrons changed across a period.

(b) Candidates often gave the configuration for aluminium rather than for the aluminium ion.

(c) (i) Some candidates were able to construct the equation for the reaction between aluminium and oxygen. Common misconceptions were that aluminium was diatomic and that oxygen was triatomic.

(ii) The term *amphoteric* was well known.

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(d) (i) Candidates could often recall the ‘dot-and-cross’ diagram for an oxygen molecule. The most common mistake was to have a single bond between the oxygen atoms.

(ii) Some candidates were able to explain that nitrogen diffuses faster than oxygen. A common misconception was that the gases had different relative atomic masses rather than different relative molecular masses. Other candidates just referred to nitrogen being lighter, which was not given any credit.

(iii) Candidates often just gave the opposite properties to those given in the question. Other candidates gave properties that were closely related e.g. the state at room temperature, boiling point and melting point and these were awarded partial credit.

Section B

Question 6

This question was about the elements in Group V of the Periodic Table.

(a) (i) Candidates often recognised that nitrogen was a liquid at –200 °C and gave appropriate explanations. Some candidates did not mention the –200 °C in their answer and gave a general answer as to why a substance was a liquid.

(ii) Many candidates could interpret the data to estimate the melting point of arsenic.

(b) Candidates found this question very demanding and often described the properties and tried to explain this property without referring to the structure and bonding. As an example, nitrogen does not have mobile electrons, but bismuth does have mobile electrons so it conducts electricity. A common misconception was to describe weak bonds in nitrogen and strong bonds in bismuth. The best answers appreciated that nitrogen had a simple molecular structure with weak intermolecular forces whereas bismuth had metallic bonding with a giant structure.

(c) Some candidates were able to construct the equation for the reaction between antimony and chlorine. Common misconceptions were that antimony was diatomic and that chlorine was triatomic.

(d) (i) Many candidates could recall that the percentage by volume of nitrogen in dry air was 78%.

(ii) Candidates found this question challenging and often did not describe both the formation of nitrogen and of carbon dioxide by a catalytic converter. The best answers illustrated their answers using equations, showing the decomposition of NO and the oxidation of CO. A common misconception was that NO was converted into NO_2 and the NO_2 was a harmless gas. A significant proportion of the candidates did not attempt this question.

(iii) The most common correct answer was lightning. Some candidates gave vague answers about chimneys and industrial waste gases.

Question 7

This question was about respiration and polymers. This was the least popular of the optional questions and candidates found many of the questions very challenging.

(a) Many candidates could construct the equation to show respiration. The most common error involved the number of moles of oxygen shown as a reactant.

(b) (i) Many candidates could give one consequence of global warming. The most common correct answers were sea-level rising and the melting of the polar ice-caps. Other correct answers given by candidates were climate change and desertification.

(ii) Some candidates did not name the processes of photosynthesis and respiration in their answers. The idea of some form of balance between the amount of each gas made and the amount used up was poorly expressed.

(c) (i) Some candidates were able to deduce that water was produced during the polymerisation; others gave formulae such as H_2O_2 or the ions H^+ and OH^-.

(ii) Most candidates were unable to give the conditions needed for the hydrolysis of starch. Correct answers either used amylase or dilute acid. Candidates confused hydrolysis with hydration and often gave the conditions needed to hydrate ethene. Some candidates did not attempt this question.

(d) (i) Some candidates could identify the amide linkage, but often extra atoms were included in their answers. A significant proportion of the candidates did not give an answer.

(ii) Candidates found this question very challenging and often gave the repeat unit or a structure with extension bonds rather than the amino acid alanine.

Question 8

This question was about chromium and some of its compounds.

(a) Many candidates recognised that the property of electrical conductivity was related to the presence of electrons; often they forgot to mention that the electrons were mobile.

(b) A significant proportion of the candidates did not know the difference between physical and chemical properties and as a result gave examples from the chemistry of transition elements. The most common correct answers involved sodium having a lower density and being softer than chromium.

(c) Candidates found this question very challenging and often neglected to refer to the different sizes of particles in an alloy. Candidates were allowed to refer to either metal ions or metal atoms in their answers but had to refer to layers of particles when describing the ease of sliding. Many candidates described atoms or ions sliding rather than layers.

(d) Some candidates could construct the reaction between chromium metal and steam. A common misconception was to write an equation for the reaction between chromium and oxygen rather than between chromium and steam.

(e) Candidates found this question quite challenging and even those who could give the correct formula forgot to include the charge on the ion.

(f) (i) Candidates found this question demanding. Many candidates did not realise that the sodium hydroxide would react with the hydrogen ions and so remove them from the equilibrium. Many candidates described the reaction of aqueous sodium hydroxide with chromium(III) compounds. Some candidates did not attempt this question. Only a very small proportion of the candidates appreciated that there would be a formation of yellow chromate(VI) ions.

(ii) Some candidates thought it was sufficient to only mention that the reaction was reversible without mentioning there were no gaseous reactants and products.

Question 9

This question was about the reaction between cerium and sulfuric acid.

(a) Candidates often forgot to qualify ideas such as less particles and less collisions. Candidates sometimes mentioned that particles were further apart or less crowded. Other candidates mentioned slower collisions rather than a reduced collision frequency. A small but significant proportion of the candidates thought that the increase in concentration would make the particles move slower.

(b) Candidates found this question less demanding than **(a)**. A significant proportion appreciated that larger pieces have a smaller surface area, so the rate of reaction is lower. A common misconception was that a larger piece of cerium has a larger surface area.

(c) Candidates could often draw the correct relative energy levels for the reactants and products in the reaction profile diagram; the enthalpy change was sometimes incorrect. Some candidates put double headed arrows without specifying that the enthalpy change was negative. Others started the line from either the activation energy hump or the *x*-axis. Most candidates included an activation energy, even though this was not needed.

(d) The best answers calculated the moles of cerium as 0.09 and then appreciated that the moles of hydrogen was 1.5 times this value. This stage was missed out by some candidates and others divided by 1.5 instead. Once candidates had obtained an amount in moles, they could often work out the volume in dm^3. Some candidates thought that volume could be obtained from multiplying the mass and the molar volume together.

(e) Candidates often calculated an incorrect relative formula but providing that the resultant calculation used two atoms of cerium, an error carried forward mark was available. Some candidates did not attempt this calculation. The best responses showed the relative formula mass calculation and the expression for the percentage along with the answer.

CHEMISTRY

Paper 5070/22
Theory

Key messages

- Many candidates need more practice in interpreting the stem of a question.
- Many candidates need to write with greater precision and to include the key terms, which will lead to a good answer.
- Many candidates need more practice in drawing the structures of organic compounds, especially branched chain compounds and polymers.

General comments

Many candidates tackled this paper well and performed well in both **Section A** and **Section B**. Most candidates gave answers of the appropriate length to questions involving free response. Most candidates responded to most parts of each question. The exceptions were **Questions 3(c)(i)** (the general ionic equation for a neutralisation reaction), **Question 5(c)(iii)** (equation for the thermal decomposition of phosphine), **Question 7(b)(ii)** (partial structure of starch), **Question 7(c)** (identification of an ester linkage) and **Question 8(a)** (metallic structure), where a significant minority of candidates did not respond.

A significant proportion of the candidates did not appear to read the stem of the question carefully enough. For example, in **Question 1(a)(iv)** many candidates did not appear to read the end of the sentence about 'three occupied electron shells. In **Question 2(a)(i)** many candidates did not refer to the equation. In **Question 3(c)(ii)** many ignored the instruction to express their answers to three significant figures. In **Question 8(b)** many candidates did not heed the words 'most metals' and gave properties that were typical of transition metals. In **Question 8(e)(i)** many candidates did not give observations, despite these being requested in the stem of the question.

Many candidates need to write with greater precision and to include key terms, which will lead to a good answer. For example, in **Question 2(a)(i)** many referred to copper (on the right of the equation) rather than copper ions (on the left of the equation), when trying to explain the reduction part of the redox reaction. In **Question 3(a)** some candidates wrote about double bonds rather than double bonds between carbon atoms. In **Question 6(c)** many candidates wrote about weak bonding in oxygen rather than weak (intermolecular) bonding between oxygen molecules. In **Question 8(f)** some candidates answered the question about alloys by suggesting that they are mixtures of elements rather than a mixture of a metal with another element. In **Questions 9(a)** and **9(b)** essential words or phrases such as more molecules <u>per unit volume</u>, more <u>frequen</u>t collisions, less <u>kinetic</u> energy and fewer <u>successful</u> collisions were omitted. Candidates should learn to focus on key terms in their proper context.

Some candidates' knowledge of organic chemistry was good. Many others need to practice drawing branched organic structures to show all of the atoms and all of the bonds (**Question 4(c)**) and in drawing the structures of a polymer from a given monomer to include the continuation bonds, which are often lacking in candidates' answers (**Question 7(b)(ii)**).

Better performing candidates often underlined or circled the key parts of the stem of the question and returned to these to check that the question had been correctly answered.

The writing of balanced equations was not always successful. Some candidates were able to work out the correct formulae for reactants and products. Others need more practice in memorising or working out simple formulae. The ‘molecular equation’ for the thermal decomposition of phosphine in **Question 5(c)(iii)** highlighted particular areas that need improvement, such as writing the formula for hydrogen as H instead of H_2. Candidates are recommended to make a list of diatomic molecules and use these in writing ‘practice equations’. Ionic equations caused particular problems in terms of identifying the relevant ions from a given ‘molecular equation’. For example, in **Question 2(a)(ii)**, many made Mg into an ion rather than identifying Cu^{2+} as the ion. Candidates should realise that it is the compound which provides the ion and not the element. They should also realise that the ionic equation for any reaction of an acid with an alkali can be represented by the combination of hydrogen ions with hydroxide ions to form water (**Question 3(c)(i)**).

Some candidates’ knowledge of structure and bonding was good. Others need further practice in distinguishing between molecular structures and giant structures (**Question 6(c)**). Candidates should be advised to check that their answers do not contain conflicting statements, e.g. ‘it is a metallic structure with strong intermolecular forces’. Others need further practice in drawing and labelling metallic structures. They should remember that they contain ions, not just positive charges, and that the ‘sea of electrons’ are between the ions and not around clusters of ions (**Question 8(a)**).

Some candidates performed well in questions involving calculations, showing appropriate working, clear progression in each step of the calculation and clear indications about what each number referred to. Other candidates should make sure that they set out each stage of their working clearly in calculations involving several successive steps, e.g. **Question 3(c)(ii)** or empirical formula calculations, e.g. **Question 4(e)(i)**. Statements in the form of moles of X = ... or from the equation moles of Y = ... can help to make clear the processes involved.

<u>Comments on specific questions</u>

Section A

Question 1

This was the best answered question on the paper with most candidates gaining marks in **(a)(i)**, **(a)(iii)** and **(a)(iv)**. In **(a)** a few candidates gave the name of the atoms or the electronic configuration instead of the letter. In **(b)(i)** a considerable number of candidates need more practice in defining the term *isotope*, paying special attention to the word ‘atom’.

(a) (i) Most candidates identified **E** as sulfur.

(ii) Many candidates correctly identified the metal atom.

(iii) Nearly all the candidates recognised **C** as having a proton number of 14.

(iv) Most candidates recognised **B** as a noble gas with three electron shells. Others chose **D**, which was another noble gas but has two electron shells. These candidates may not have read the question fully.

(v) The most common incorrect answers were **B** or **D**. Candidates who chose these noble gas structures did not read the question fully to include the last phrase ‘when it loses two electrons’.

(b) (i) Many candidates gave definitions that did not include the term *atom*, often using the word element instead of atom. Others reversed protons and neutrons or referred to relative atomic mass. Candidates should be encouraged to make a list of the chemical definitions that appear in the syllabus together with their meanings and underline the important parts of the definition.

(ii) The majority of candidates deduced the correct number of neutrons. A considerable minority gave the symbol for the isotope either as subscript or superscript, e.g. Ge^{44}. This should be discouraged. Others either gave more than one number or added the number of protons to the mass number.

Question 2

Some candidates answered this question well. Others need more practice in answering questions precisely ((**a**)(**i**)), constructing ionic equations ((**a**)(**ii**)) and in learning qualitative tests ((**c**)).

(a) (i) Many candidates did not respond to this question with the precision required and gave answers that referred to the gain and loss of oxygen. Those candidates who gave better answers, recognised that magnesium was oxidised by reference to either the increase in the oxidation state or the loss of electrons. The reduction was less well explained, often incorrectly, in terms of either copper or copper sulfate gaining electrons rather than the copper ion gaining electrons. A small proportion of candidates just gave a definition for redox in terms of electron loss and gain. Others just mentioned that reduction and oxidation took place and made no attempt to relate this to the actual reaction. Candidates should be encouraged to read the question carefully and refer to the equation when requested.

(ii) A large variety of incorrect ionic equations were given. These often involved a magnesium ion rather than a magnesium atom. Many candidates included the sulfate ion in their equation. A small proportion of the candidates gave the formulae of the ions as Mg^+ and/or Cu^+. A considerable minority of the candidates wrote either equations showing all the ions or wrote half equations, e.g. $Cu^{2+} + 2e^- \rightarrow Cu$. Many suggested $Mg^{2+} + SO_4^{2-} \rightarrow MgSO_4$.

(b) Candidates often gave a diagram that was recognisable as the purification of copper. The use of copper sulfate solution as the electrolyte was well known but often the electrodes were either not identified or given the wrong way around. Others labelled the anode and cathode but did not state which was pure / impure.

The correct symbol for a battery was well known but its polarity was not. A small number of candidates drew circuits that were short circuited.

(c) The most common misconception was to describe the displacement reaction in the electrolysis in **(b)**; as a result, a pink solid was often mentioned. The most common incorrect coloured precipitate suggested was a white precipitate. The idea that a blue precipitate would dissolve to give a dark blue solution was quite well known but many suggested that the dark blue precipitate was insoluble. Others did not qualify the blue colour of the solution by adding the word ‘deep’ or ‘dark’. Candidates should be encouraged to learn the qualitative tests in detail.

(d) Some candidates confused this type of sacrificial protection with the idea of a barrier protection. The idea that magnesium was more reactive than iron was often well expressed but sometimes the answer then mentioned the formation of a layer of magnesium oxide being formed. A significant proportion of the candidates mentioned magnesium rusting rather than corroding. Candidates could improve their answers by realising that it is only iron that rusts.

Question 3

Some candidates gave good answers to parts **(a)** and **(b)** of this question. Better performing candidates in **(c)(i)** realised that all reactions involving the addition of acid to an alkali can be represented by the equation $H^+ + OH^- \rightarrow H_2O$. The calculation in **(c)(ii)** was generally answered well. Candidates should be encouraged to read the question carefully and note the number of significant figures required for the answer.

(a) Many indicated a carbon-carbon double bond. Others gave answers that were imprecise and just mentioned the presence of a double bond but not that it was between carbon atoms. The best answers clarified their written response by using C=C. Candidates should realise that it is the C=C bond and not the C=O bond which makes the compound unsaturated.

(b) The colour change was well known and only a small proportion of candidates reversed the colours or gave orange to green (the colours for the reaction with acidified potassium dichromate(VI)). At this level, it would be advisable not to mention this reagent. Another common error was to suggest a colour change of red to blue.

(c) (i) A minority of the candidates wrote the correct ionic equation involving the reaction of hydrogen ions with hydroxide ions. Others gave ionic equations that included sodium ions and formulae related to fumaric acid but these were hardly ever correct. Common misconceptions included writing fumaric acid as COOH and its ion as COO^- rather than including the full formula. Many unbalanced equations were seen.

A considerable proportion of the candidates did not answer this question.

(ii) The best answers were well laid out showing the amount in moles of fumaric acid and of sodium hydroxide before calculating the volume. Candidates should be encouraged to read the question carefully and note the number of significant figures required for the answer. Many candidates gave their answer to just two significant figures rather than the required three. Some candidates did not convert the volume in dm^3 to cm^3 and others forgot to give the correct units when giving an answer of 0.0160. A common incorrect answer was 8.00, obtained through not considering the mole ratio of acid to alkali in the equation. Many candidates could improve their marks by considering the second step by reference to the correct mole ratio in the equation.

Question 4

This question was well answered by some candidates. In **(b)** many were able to balance the equation. A minority of the candidates were able to draw the structure of a branched alkene correctly in **(c)**. Others need more practice in drawing organic structures and should take care to follow the instructions to show all of the atoms and all of the bonds. In **(d)** some candidates were able to name the product correctly and most were able to give the purpose of using nickel in this hydrogenation reaction. Others need to learn appropriate organic nomenclature. In **(e)** many candidates were able to deduce the correct empirical formula for the hydrocarbon. Fewer knew that relative molecular mass is required in order to deduce the molecular formula. Others can improve their marks by learning the standard procedure for this type of calculation, i.e. deduce the percentage of each type of atom present, divide percentage of each element by its relative atomic mass then divide by the smallest number.

(a) The best answers referred to the same functional group or same general formula or similar chemical properties. Some candidates misinterpreted the question and gave answers that related specifically to the homologous series of alkenes. A significant number of candidates referred to the same chemical properties, rather than similar chemical properties, or similar physical properties, rather than referring to a trend in physical properties. Candidates often gave an example of a trend in a physical property, typically the boiling point, which was acceptable. Other common errors included ‘same formula’ or ‘same molecular formula’.

(b) Some candidates were able to balance the chemical equation, providing they appreciated that there was a reaction with oxygen to give carbon dioxide and water. Some candidates did not give oxygen as a reactant or gave hydrocarbon products in addition to the correct combustion products. Others suggested that hydrogen was a reactant or product. Those who deduced the correct reactants and products usually balanced the equation correctly. Many candidates did not realise that carbon dioxide and water are the only products formed when any hydrocarbon undergoes complete combustion.

(c) A minority of candidates were able to draw a branched alkene containing four carbon atoms. The best answers were well spread out showing each bond clearly. The most common incorrect answers were straight chains, either of but-1-ene or but-2-ene. Other candidates bent the chain giving an L-shaped structure. Other candidates drew structures with trivalent carbon atoms in a straight chain. Some candidates who drew a branched chain often included pentavalent carbon atoms. Others did not include the double bond or did not show all of the atoms and all of the bonds. Candidates should practice drawing different isomers of particular hydrocarbons.

(d) (i) Some candidates realised that butane is formed by hydrogenation of butene. Others gave incorrect names such as butanol or nickel compounds. Many suggested margarine.

(ii) A majority of candidates understood the purpose of nickel in the reaction. Most correctly referred to nickel being a catalyst. A small proportion of the candidates misinterpreted the question and gave other uses of nickel, e.g. coins.

(iii) The conditions for this hydrogenation were not well known and candidates were much more likely to be awarded a mark for just mentioning heat or a high temperature than quoting the correct temperature range. The temperature was often too high, e.g. 200 or 400 °C being commonly seen. Many thought that pressure was significant.

(e) (i) The most common error made was in not calculating the percentage of hydrogen in the hydrocarbon, and therefore trying to do the calculation with only the data for carbon and ending up with an answer like C_7H_x. Other candidates used the same percentage for hydrogen as for carbon or inverted the expression for the amount in moles. Those candidates that did calculate the percentage by mass of hydrogen were normally able to give the empirical formula as CH_2. Candidates should learn the standard procedure for this type of calculation, i.e. deduce the percentage of each type of atom present, divide percentage of each element by its relative atomic mass then divide by the smallest number.

(ii) A minority of the candidates appreciated the need for the relative molecular mass. Others thought that the percentage of hydrogen in the compound was required, presumably because they had not appreciated how to calculate this piece of information in **(e)(i)**. Other incorrect answers included the general formula, relative atomic mass, mass of a molecule or molecular formula.

Question 5

This question was well answered by many candidates. The electronic configuration of the phosphide ion in **(b)** was often correct and a majority of the candidates were able to draw the correct 'dot-and-cross' diagram for phosphine in **(c)(i)**. The parts which were least well answered were **(c)(iii)** (equation for the thermal decomposition of phosphine) and **(c)(v)** (classification of phosphorus(V) oxide).

(a) The best answers related group number to the number of valence electrons and the period number to the number of electron shells. Many candidates included extra information such as chemical properties (reactivity) and physical properties (melting point and density) as well as information from the atomic structure. Other common answers included the proton number. Only a small proportion of the candidates just mentioned the electronic configuration. Many candidates omitted the essential word 'number', e.g. 'the outer shell electrons tell you the group'.

(b) Many candidates deduced the correct electronic configuration. Others gave the configuration for phosphorus rather than for the phosphide ion. A very small proportion of the candidates removed three electrons to give an answer of 2,8,2. Some candidates thought that phosphide ions had 34 electrons and gave the answer as 2,8,8,8,8.

(c) (i) Many candidates were able to draw the correct 'dot-and-cross' diagram for phosphine. A minority forgot the lone pair of electrons and a few candidates drew ionic formulae.

(ii) Many candidates mentioned that ammonia was soluble in water and that ammonia turns red litmus blue. Others had the litmus colours reversed. The most common misconception was that ammonia was easily decomposed and some candidates thought this would be a difference because nitrogen would be formed rather than phosphorus. Another common error was to suggest that ammonia does not react with hydrogen chloride.

(iii) A minority of the candidates knew that the formula for phosphorus is P_4. The main errors were P_2 as a product and H instead of H_2 for hydrogen. Some candidates need further practice in developing strategies for balancing equations because many of them did not balance the equation correctly even when the formulae were correct. A considerable proportion of the candidates did not answer this question.

(iv) The best answers included reference to both a comparison of rate of diffusion of ammonia and phosphine and the difference in their relative molecular masses. Some candidates knew the ammonia would diffuse faster than phosphine but they were not always able to explain why, in terms of relative molecular mass. Candidates sometimes just referred to ammonia being lighter or having a lower density without any further reference. A minority of candidates suggested that phosphine diffuses faster because of its higher relative molecular mass.

(v) The best answers suggested that phosphorus(V) oxide is an acidic oxide and related this to the fact that phosphorus is a non-metal rather than relating it to its position in the Periodic Table. A minority of candidates suggested that phosphorus(V) oxide was an acidic oxide but many of those who appreciated this did not give an appropriate explanation. Others gave a definition of an acid or referred vaguely to an acid. The most popular answer was 'amphoteric'. A considerable number of candidates suggested 'basic'.

Section B

Question 6

Most candidates gave good answers to **(a)(i), (b)(i)** and **(b)(ii).** Some candidates gave good answers to **(a)(ii)** and **(d)**. Others need to answer questions with greater precision especially when interpreting information from a table (**(a)(ii)**) or describing how acid rain is formed (**(d)(ii)**). Few candidates gave convincing arguments to explain the difference in the structure and bonding of oxygen and polonium in **(c)** and few used the information in the table to guide them. In this type of question, candidates should be clear that the term *intermolecular forces* should not be used when referring to metals or covalent giant structures. They should also be encouraged to use the information in tables to ascertain the type of structure e.g. polonium is a metal because it is a good electrical conductor.

(a) (i) Nearly all candidates could use the information in the table to deduce a suitable value for the density of selenium.

(ii) The best answers referred to the liquid state because –190 °C is between the melting point and the boiling point. Some candidates did not mention the –190 °C in their answer and gave a general answer as to why a substance was a liquid. Others only quoted the data or referred to the melting or boiling point but not both. Some candidates would benefit from improving their mathematical skills in interpreting the relative values of negative numbers.

(b) (i) Many candidates were able to interpret the information about electrical conductivity and give a description of the direction of the trend. A small proportion of the candidates did not describe whether the trend they were describing was either up or down the group.

(ii) Some candidates recognised that either tellurium or polonium did not follow the trend. Many candidates offered confused or vague explanations. A common error was to refer to oxygen since it had a negative value for the melting point.

(c) The best answers referred to oxygen being a simple molecule and polonium having metallic structure and bonding. Many candidates did not obtain the available marks because they described the properties and tried to explain this property without stating the structure and bonding. For example, oxygen does not have mobile electrons, but polonium does have mobile electrons so polonium conducts electricity. A common misconception was to describe weak bonds or weak forces in oxygen without stating where the weak forces or weak bonds were, i.e. within or between the molecules. Many candidates just restated data from the table. Many suggested strong bonds in polonium without qualification and a few suggested that the bonding was ionic. The most prevalent error was to write about intermolecular forces in polonium. In this type of question, candidates should be clear that the term *intermolecular forces* should not be used when referring to metals or covalent giant structures. They should also be encouraged to use the information in tables to ascertain the type of structure, e.g. polonium is a metal because it is a good electrical conductor.

(d) (i) Many candidates gave vague answers such as 'gases from industry'. The best answers involved writing about volcanic eruptions or burning fossil fuels such as coal. The most common incorrect answers were: car fumes; factories; smoke; car engines or burning fuel (unqualified).

(ii) Many candidates wrote confused answers and rarely mentioned sulfur dioxide reacting with both water and oxygen. Common misconceptions included sulfur dioxide reacting with carbon dioxide or carbon monoxide, or sulfur reacting with oxygen to make sulfur dioxide. Candidates were more likely to mention the formation of sulfuric acid than sulfurous acid. Many did not mention oxidation in air/oxygen. The best answers described the oxidation of sulfur dioxide in the air to form sulfur trioxide and the subsequent reaction of sulfur trioxide with water to form sulfuric acid. Some candidates suggested that the sulfur dioxide or sulfur trioxide dissolved in the water rather than reacted with the water without any further qualification such as 'sulfurous acid formed'.

Question 7

Some parts of this question were well answered by many candidates. The equation and conditions for photosynthesis in **(a)** were generally well known and many candidates identified the type of polymerisation in **(b)(i)**. The exceptions were **(a)(iii)** where candidates did not focus on both renewable energy and the source of this energy, **(b)(ii)** drawing the partial structure of starch, **(b)(iii)** identifying hydrolysis and **(c)** identification of the ester linkage.

(a) (i) The majority of candidates were able to write the balanced equation for photosynthesis. The main errors were either to omit oxygen as a reactant or put carbon dioxide or ethanol as incorrect reactants. A minority of candidates did not balance the equation correctly.

(ii) Most candidates were able to give at least one condition for photosynthesis. The most common correct answers were light and chlorophyll (as a light-transfer molecule). A small proportion of candidates gave a temperature value that was outside the range of 0–50 °C. The presence of water and carbon dioxide were mentioned by candidates but not given credit since these are reactants rather than conditions.

(iii) Very few candidates were able to give a correct answer. Good answers included the formation of starch/glucose by plants which can be fermented to ethanol and used as a fuel or the production of wood for heating. Many candidates focused on the renewable part of the question but did not use ideas about an energy source. Many wrote vague statements about the cycle of photosynthesis and respiration. Others just stated that 'plants can be regrown' or 'plants make glucose' without any further discussion. A number of candidates referred to the everlasting nature of the Sun but did not state how sunlight is converted into a useful form of energy.

(b) (i) Many candidates referred to condensation (polymerisation); others incorrectly mentioned addition.

(ii) The best answers showed two or more boxes linked by –O– with continuation bonds at either end to show that this was only part of the chain. Many candidates gave structures that still had the OH group included or had an –O–O- linkage. A minority of candidates linked the boxes with –H–H–. A considerable number of candidates did not draw continuation bonds on one or both sides of the structure. A considerable number of candidates did not answer this question.

(iii) A minority of the candidates recognised the reaction as hydrolysis. Other candidates referred to hydration or digestion. A misconception was to give the name of an enzyme that hydrolyses starch. Many candidates appeared to guess the answer, leading to suggestions such as hydration, oxidation, fermentation or displacement. A considerable proportion of the candidates did not write a response to this question.

(c) Some candidates recognised the ester linkage; others included extra atoms. Many split the structure in half and drew two large circles. This suggests that they confused the ester linkage with the repeat unit. Others drew circles around the oxygen atoms, CH_3 group or CO group.

Question 8

This was the least well answered question on the whole paper. In **(b)** many candidates were able to describe two physical properties of metals. Others did not appear to read the question carefully and gave properties of transition elements rather than general metallic properties. Some candidates gave a good definition of the term *alloy*. Others omitted the essential word 'mixture'. A minority of the candidates gave convincing answers to **(a)** (structure of metals), **(d)** (formula of an ion) and **(e)** (equilibrium). Most candidates need to revise these areas more thoroughly by understanding the position and type of particles present in a metallic structure and looking carefully at the state symbols in equilibrium equations.

(a) The best answers showed electrons between the circles and labelled electrons and + charges in the circles, the circles being labelled positive ions. Some candidates did not draw the electrons in between the circles but drew them on the outside around the whole structure. Others drew an ionic structure with some of the circles annotated with a negative sign and others with a positive sign. A significant number of candidates thought that the ions were protons. A considerable number of candidates either did not respond to this question or did not annotate their diagrams.

(b) Many candidates were able to identify at least one physical property of metals. Others were not always able to distinguish the properties of transition elements from those of typical metals and as a result included high density, high melting and boiling point and strength in the answer. Many candidates put more than three properties down. The most common properties that were given credit were conducts heat and/or electricity, ductile and malleable. A few candidates gave chemical properties or wrote about coloured compounds.

(c) Some candidates were able to balance the equation, sometimes by balancing with $1\frac{1}{2}Cl_2$, which was acceptable. Common misconceptions included having diatomic bismuth and/or monatomic chlorine.

(d) Some candidates gave the correct formula but did not gain credit because they forgot to include the charge on the ion. Other candidates gave formulae such as $BiCl_4^-$ or Bi_2Cl_6.

(e) (i) Many candidates did not read the question carefully and did not include an observation, even if they appreciated that the equilibrium would shift to the left. Common misconceptions included the formation of bubbles or gases not mentioned in the equation, for example forming hydrogen from the acid. A considerable minority discussed rate of reaction rather than equilibrium.

(ii) Some candidates thought it was sufficient to only mention that the reaction was reversible without mentioning there were no gaseous reactants and products. Others only compared the number of moles on each side of the equation rather than discussing gases. In this type of question, candidates should be advised to look carefully at the state symbols in the equilibrium equation.

(f) A significant proportion of the candidates thought that an alloy was a compound rather than a mixture. Most candidates mentioned metals with other metals in their answer. Fewer included the essential word 'mixture'. A small number of candidates confused alloys with allotropes or isotopes. Others wrote about mixtures of metals combined, not appreciating the chemical meaning of 'combined'. Candidates should be encouraged to make a list of the chemical definitions that appear in the syllabus, together with their meanings, and underline the important parts of the definition.

Question 9

This was the best answered question from **Section B**. The energy profile diagram in **(c)** and the calculations in **(d)** and **(e)** were generally well answered. In **(a)** and **(b)** many candidates did not answer the questions about the effect of concentration and temperature on rate of reaction with the precision required.

(a) The best answers referred to more particles per unit volume and increase in collision frequency. Many candidates did not qualify their ideas and just referred to more particles without reference to volume, area or cm^3. Candidates sometimes mentioned that particles were closer together or more crowded and this was given credit. Other candidates mentioned faster collisions rather than a greater collision frequency. A small but significant proportion of the candidates thought that the increase in concentration would make the particles move faster or have more energy. For the second marking point a common error was to suggest more collisions rather than more frequent collisions.

(b) The best answers referred to the idea that particles would move slower or have less kinetic energy and linked this to either fewer successful collisions or fewer particles having energy less than the activation energy. A significant number of candidates did not receive credit because they wrote answers that were not precise enough. For example, 'less energy' rather than 'less kinetic energy' or 'fewer collisions' rather than 'fewer successful/effective collisions'. Only a very small proportion of the candidates referred to activation energy within their answer. Others mentioned activation energy but suggested that 'the particles do not reach the activation energy' or that 'the activation energy is lowered'. Candidates should be aware of the important words such as 'kinetic' and 'successful' or 'effective' in the correct context.

(c) Many candidates drew the correct relative levels for the reactants and products in the energy profile diagram. Fewer gained credit for the enthalpy change. For example, some candidates put double headed arrows without specifying that the enthalpy change was negative. Others started the arrow line from either the activation energy hump or the *x*-axis or confused activation energy with enthalpy change. It should be noted that the drawing of an activation energy hump was not necessary to answer this question, so the inclusion of it by most candidates often led to confusion between the arrows. Candidates should be advised that they should not include material that is not asked for in their answers, since this can lead to errors being made. Some candidates drew the energy profile diagram for an endothermic reaction.

(d) Many candidates correctly calculated the volume of hydrogen. Most worked out the moles of zinc as 0.07 moles and many appreciated how to calculate the volume from this value. Other candidates thought that the volume was mass × 24 or calculated the moles of zinc from the relative formula mass of sulfuric acid. A significant number of candidates divided the moles by 24. A few candidates used an incorrect relative atomic mass for zinc; 56 rather than 65, being the most common error.

(e) Many candidates correctly calculated the percentage by mass of zinc. Some candidates calculated the relative formula mass for zinc phosphate incorrectly. The most common incorrect formula mass was 185. Some candidates did not appreciate that the numerator of the fraction used to calculate the percentage, had to have three zinc atoms rather than just one.

CHEMISTRY

Paper 5070/31
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 involved tests given in the Qualitative Analysis Notes and redox reactions. Candidates that were able to follow instructions involving test-tube reactions and the accurate recording of observations performed well.

General comments

Overall, candidates were able to carry out the titration involved in **Question 1**; the subsequent calculations proved more challenging for some.

All the candidates attempted the tests in **Question 2**; there was considerable variation in the quality and the accuracy of the observations recorded.

Comments on specific questions

Question 1

(a) The results table was mostly completed correctly. The best titres were usually selected; there was variation in their accuracy. Once two concordant titres are obtained, there is no benefit to be gained from performing additional titrations.

(b) Not recognising the difference in volume units between the concentration of **Q**, dm^3, and the average titre, cm^3, led several candidates to simply multiply 0.105 by the average volume of **Q**. A few candidates attempted to calculate the concentration of sodium hydroxide rather than answer the question.

(c) The majority of the responses correctly multiplied the answer in **(b)** by 2.

(d) Following on from their mistake made in **(b)**, many candidates divided the number of moles of sodium hydroxide by 25.0.

(e) The majority correctly determined the mass of sodium hydroxide in **P**.

(f) There were several candidates who were unable to calculate the mass of water present.

(g) Some candidates were not able to calculate the percentage by mass of water in the damp sodium hydroxide.

Question 2

There were numerous examples where correct observations were made but they were not complete e.g. if bubbles are seen then the gas must be tested and identified or if a reagent is added to excess, the result of the excess addition must be reported.

It is important that the reporting of observations uses appropriate language e.g. a milky green colour is not an acceptable alternative for a green precipitate; a precipitate turns colourless is not equivalent to the precipitate dissolves and forms a colourless solution. Candidates should make full use of the Qualitative Analysis Notes supplied on the last page of the examination paper.

Test 1

There were a considerable number of responses that did not record the colour of the paper which indicated that the solution was alkaline.

Test 2

A white precipitate was reported by many; not all noted its disappearance in excess of **R** and, for those who did, few described the final solution as colourless. It was essential for candidates to follow the instructions, regarding the addition of **R,** to obtain the correct observations.

Test 3

A green precipitate was generally seen but its insolubility in excess reagent was not always noted; there were a few responses that stated the solid disappeared when an excess of the reagent was added.

Test 4

Many candidates did not detect the ammonia gas produced.

Test 5

The white solid generally reported in **(a)** did not always dissolve in **(b)** and when it did, the final solution was rarely reported to be colourless.

Test 6

An acceptable colour of iodine was often recorded in the observations but it was not always clear at what stage in the test the colour appeared. One or two drops of **S** produces a little iodine and the solution turns yellow. The addition of more **S** produces more iodine so the colour darkens and if the mixture is left to stand, black solid iodine forms.

Test 7

The most frequent observation that gained credit was that the (purple) solution turns colourless, though there were a few candidates who inaccurately reported ‘turns clear’. Some noted the bubbles formed, but it was rare for candidates to conduct a test for oxygen.

Test 8

The addition of **S** to the iron(II) ions causes the solution to turn yellow or brown. A number of candidates missed this observation and just recorded the red-brown precipitate formed when **R** was added. The insolubility of the solid in excess **R** was rarely noted. Bubbling was occasionally seen but, as in **test 7**, the oxygen was not often identified.

Conclusions

Few candidates managed to correctly identify ammonia as the compound in **R**.

Only some of those, who had reported the decolourisation of manganate(VII) in **test 7**, suggested that **S** was a reducing agent.

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 involved tests given in the Qualitative Analysis Notes and redox reactions. Candidates that were able to follow instructions involving test-tube reactions and the accurate recording of observations performed well.

General comments

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

All the candidates attempted the tests in **Question 2**; there was variation in the standard of the observations recorded.

Comments on specific questions

Question 1

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

(b) Not recognising the difference in volume units between the concentration of **Q**, dm^3, and the average titre, cm^3, led some candidates to produce values that were 1000 times too large.

(c) The majority correctly divided the answer in **(b)** by 2; a few multiplied by 2 or overlooked the equation given.

(d) A few ignored their answer to **(c)** and calculated the concentration of **P** from scratch i.e. by using all the volumetric data and the mole ratio for the reaction.

(e) Despite the instruction provided in the question, a considerable number multiplied 106 by the answer to **(c)**.

(f) Candidates found this question and **(g)** the most challenging. Candidates with responses with a mass in **(e)** greater than 12.27 g rarely chose to re-examine their earlier working. Others did not use their answer to **(e)** and calculated another value, sometimes using the relative mass of water.

(g) When the answer in **(f)** exceeded 12.27 g, few candidates were prepared to produce a percentage that was in excess of 100% and so inverted the ratio. Some simply used other ratios such as $\frac{5.90}{12.27}$.

Question 2

Candidates who had most success with this question demonstrated proficiency in carrying out the analysis tests and had an understanding of the chemistry involved. The observations reported in **tests 4** and **5** revealed confusion over the use of aluminium and alkali in the test for nitrate ions.

Test 1

Most noted that **R** turned red litmus blue; there were some who saw no change.

Test 2

A white precipitate was reported by many; not all noted it did not dissolve in excess of **R**.

Test 3

Adding **R** too quickly resulted in candidates not seeing the green precipitate and so the only observation that could be recorded by these candidates was that a green solution formed.

Test 4

Few of the candidates who recorded bubbling when **R** and aluminium were warmed together, identified the gas as hydrogen. Many incorrectly reported that the gas turned damp red litmus blue, presumably because the paper was contaminated by the alkaline solution. Even the smell of ammonia was noted by some.

Test 5

Many of those who erroneously detected ammonia in **test 4** missed the ammonia produced when the nitrate present here, was reduced.

Test 6

A pale yellow precipitate is formed on addition of aqueous silver nitrate to **S** and remains upon addition of the nitric acid. A number believed the solid only appeared when the acid was added and some reported the precipitate from **(a)** dissolved in the acid.

Test 7

One or two drops of aqueous hydrogen peroxide added to acidified **S**, produces a little iodine and the solution turns yellow. The addition of more peroxide produces more iodine so the colour darkens and if the mixture is left to stand, black solid iodine forms. Many gained both marks; there were some who reported coloured precipitates in **(a)**.

Test 8

Iodine is produced and then the addition of starch turns the mixture blue/black. The test was generally performed well by candidates.

Test 9

If the quantities specified were used and the liquids mixed thoroughly, the correct observations were obtained. In **(a)**, iodine is produced. When **R** is added in **(b)**, the colour becomes paler as the iodine is removed but the addition of acid in **(c)**, reforms iodine so the colour reappears/darkens.

Conclusions

Many correctly identified the anion in **S** as iodide; fewer correctly answered that **R** contained hydroxide ions. The most commonly suggested incorrect anion in **R** was nitrate.

CHEMISTRY

Paper 5070/41
Alternative to Practical

Key messages

- Candidates generally showed a good understanding of many of the practical techniques outlined in the syllabus.
- Aspects that candidates found most difficult were in planning and evaluating practical techniques. Candidates need to be able to devise a plan for an experiment and express their ideas in a clear and logical order. They also need to be able to consider a given method and identify any weaknesses or omissions in the method. In particular, they need to be able to identify potential hazards and suggest reasoned improvements. Candidates need to suggest improvements that are specific to the task or the chemicals involved rather than making generalised statements.

General comments

The alternative to practical paper is designed to test candidates' knowledge and understanding of practical chemistry.

Candidates need to know the practical techniques and also to be able to demonstrate an understanding of how and why these techniques are applied to specific contexts. This includes being able to select suitable equipment for a task and to state why one piece of equipment is more suitable than another.

Comments on specific questions

Question 1

Most candidates were able to identify the two pieces of equipment. Some candidates thought that a pipette was a burette. When describing a flask, it is important to be specific. The full description of a conical flask is needed rather than just a flask.

Question 2

(a) This question was generally well answered. Some candidates reversed the answers.

(b)(i) and **(ii)**
These questions required the candidates to say why **Z** was **more** suitable than **Y** or **X**. It was not sufficient to simply state that the gas was insoluble.

Question 3

(a) Fume cupboards are used to prevent toxic gases escaping into the atmosphere. Candidates often wrote more generalised answers using words such as 'dangerous', which was not given credit. Better performing candidates knew the hazards associated with common substances and were able to state which substance is toxic.

(b) (i) This question was generally well answered. Some candidates wrote suggestions that were not variables or repeated the variable stated at the start of the question.

(ii) This was generally well answered by candidates who had selected an appropriate variable in **(b)(i)**.

(c) (i) Nearly all candidates were able to complete the table correctly. Some candidates left this blank.

(ii) Most candidates recognised that the last experiment was the fastest.

(iii) Candidates often wrote answers based on their theoretical knowledge rather than referring to the results in the table, as required by the question. These theoretical answers often included reference to the increase in the number of collisions as concentration increases. These responses did not answer the question that was set. When candidates did use the table of results most referred only to time. Very few candidates attempted to make a link between time and rate.

(d) (i) Most candidates who attempted this part were able to correctly calculate the number of moles.

(ii) There was a wide variety of answers to this question. Candidates who were unable to answer this often tried to use formulae relating to mole calculations rather than simply looking at the table of results.

(iii) Few candidates were able to calculate this correctly. The calculation required the use of the candidates' answers to **(d)(i)** and **(d)(ii)**. Some candidates correctly divided **(d)(i)** by **(d)(ii)** but used the volume in cm^3 rather than converting the volume to dm^3 to get the concentration in the units shown in the question.

(e) The test for sulfur dioxide gas seemed to be less well known than tests for other gases.

(f) The test for sulfite ions was not well known. Many candidates gave the test for sulfate ions rather than sulfite. Others gave the test for sulfur dioxide as well as, or instead of, in **(e)**. The test given in the syllabus is to add acid and test for sulfur dioxide. Where candidates chose to add barium nitrate or barium chloride then sulfite can be identified by adding the barium nitrate and observing a white precipitate, which then dissolves when nitric acid is added. If sulfate ions were present the precipitate would not dissolve in acid.

Question 4

(a) Almost all candidates were able to complete this calculation correctly.

(b) Many candidates were able to suggest suitable methods. Some candidates thought that a change in pressure or the use of a catalyst would be suitable. These are inappropriate for this context.

(c) Few candidates were able to answer this question correctly. Some candidates realised that the beaker needed to be washed with water, without mentioning that the washings must be added to the conical flask.

(d) Most candidates were aware that the answer related to accuracy. However, in order to answer the question fully the accuracy of the pipette needed to be compared with the accuracy of the measuring cylinder. A statement such as 'the pipette is accurate' was insufficient to gain credit.

(e) (i) Most candidates knew the two colours. However, many candidates thought the colour change was from pink to colourless rather than colourless to pink.

(ii) Most candidates could read the scales correctly, complete the subtractions and calculate the average. A few candidates tried to read the burettes in the wrong direction, for example, taking the first 'final burette reading' as 27.7 rather than 26.3. Some candidates used all of the titration results to calculate the average rather than the best titration results as required by the question.

(f) Few candidates showed an understanding of the idea of concordant results in a titration.

(g) Most candidates could complete this calculation.

(h) Few candidates were able to use the mole ratio given in the question to multiply their answer from **(g)** by $\frac{5}{2}$. Many candidates simply multiplied by 5 instead.

(i) Most candidates realised that they needed to multiply their answer in **(h)** by 10.

(j) Many candidates knew to divide **(a)** by **(i)** to obtain this answer.

(k) Candidates who had got **(g)** to **(j)** correct were generally able to answer this correctly. Some of these did not realise that the answer should be a whole number. Candidates who had made one or more errors in parts **(g)** to **(j)** found it more difficult to apply their figures to this part of the question, as they often ended up with negative numbers.

Question 5

Candidates often had difficulty in expressing their ideas in a clear and logical way. There was confusion in some of the answers as to which substance was being tested. The tests were generally quite well known, with the test for an alcohol being the least well known. Candidates sometimes contradicted themselves in their answers by mixing up tests or giving the wrong tests for gases. For example, a candidate adds magnesium to an acid and knows that hydrogen is formed but then states that it is identified with a glowing splint or with limewater. In the test for ethanol, not many candidates stated that heat was required. Some candidates chose to use additional chemicals that were not included in the question.

Candidates found it easier to apply their knowledge in questions related to qualitative analysis in a structured format, as in **Question 6**, than in this question where they needed to plan the tasks.

Question 6

(a) (i) Answers were often lacking in specific detail. It is a transition metal ion in a compound that causes colour, not the transition metal itself. Candidates therefore needed to state that the colourless solution indicated the absence of a transition metal ion in the compound **L** rather than stating that substance **L** is not a transition metal.

(ii) Most candidates knew the test for carbon dioxide.

(iii) Most candidates knew that a carbonate produces carbon dioxide.

(b) Many candidates suggested suitable ions in **(i)**. Fewer were able to identify calcium or magnesium as the ion that had an insoluble precipitate in excess sodium hydroxide in **(ii)**.

(c) Many candidates knew this test. Some candidates did not mention that heat is needed. Some did not mention the name of the gas produced or the test to identify it. A very few candidates used the brown ring test rather than the test with aluminium or Devarda's alloy; this was acceptable if described correctly.

Question 7

(a) Few candidates understood that an excess of copper is used to ensure that all of the oxygen had reacted. Stating that all of the air reacted was not appropriate in this context. Many candidates said that it was to make sure that the reaction was complete. This was insufficient, as copper would completely react if less than an excess was used.

(b) Few candidates were able to relate their answers to the fact that the volume measured would be different at different temperatures because gases expand when heated. Most answers were vague or generalised, for example, 'to get an accurate volume'.

(c) (i) Most candidates could plot the points correctly. Fewer were able to draw a good line of best fit to the points. Some candidates wanted the line to go through every point. Some candidates did not read the part of the question that asked them to extend the line to the edge of the grid.

(ii) Most candidates correctly circled the anomalous point even if they had drawn the line to go through it. Some candidates drew a circle that enclosed more than one point.

(iii) Candidates were told that there was no error in reading the volumes; despite this information being included in the question, this was often the reason given.

(d) (i) Many candidates were able to read this value correctly from their graph. A few read the value where the line reached the grid rather than at 100 cm^3.

(ii) It was essential that candidates showed their working in this question. Many candidates were able to subtract their value in **(d)(i)** from 100 to obtain this value. Some candidates divided by 100 and also multiplied by 100, which was unnecessary but acceptable. Candidates who were unable to complete part **(d)(i)** usually omitted this part.

CHEMISTRY

Paper 5070/42
Alternative to Practical

Key messages

Candidates should be aware of the practical techniques required to:

- increase the rate of a reaction between a solid and an aqueous solution
- completely transfer the contents of a container into another container without leaving anything behind in the first container
- keep the contents of a container at a constant temperature throughout an experiment
- identify the anions, cations and gases listed on the syllabus.

General comments

The alternative to practical paper is designed to test candidates' knowledge and understanding of practical chemistry.

Candidates need to know the practical techniques and also to be able to demonstrate an understanding of how and why these techniques are applied to specific contexts. This includes being able to select suitable equipment for a task and to state why one piece of equipment is more suitable than another.

Comments on specific questions

Question 1

This question was answered very well by almost all of the candidates.

Question 2

(a) Bromine was occasionally identified as a solid or as a precipitate. The evolution of chlorine was only rarely described as effervescence, bubbling or fizzing. Potassium was often seen as a product, instead of hydrogen. Copper was occasionally described as blue or black.

(b) This was generally answered well. Some candidates said that litmus would turn blue as well as, or instead of, being bleached.

Question 3

(a) Pressure was often given as an answer despite the fact that the reaction was between a solid and an aqueous solution. Temperature was occasionally seen as an answer even though the question referred to constant temperature. The mass of calcium carbonate was also given as an incorrect response.

(b) (i) Heat loss to the surroundings was only occasionally given as a correct answer.

(ii) Candidates should be aware that a thermostatically controlled water bath can be used to keep the temperature of a reaction mixture constant. There are other suitable methods that candidates may be familiar with. If an electric heater was suggested it should have been qualified by reference to temperature control. It would be extremely difficult to keep the temperature constant using a Bunsen burner.

(c) (i) This was answered reasonably well. Experiment 5 was seen as the most common incorrect answer.

(ii) Many candidates suggested plotting a graph; there was often no explanation of what to do once the graph was plotted.

(iii) This was answered reasonably well. Some candidates unnecessarily referred to temperature.

(iv) This was answered reasonably well. Some candidates chose experiment 1.

(v) This was answered reasonably well. Some candidates stated that the rate increased without any reference to temperature.

(d) This was answered reasonably well. Some candidates said that the temperature was too high without further explanation. Saying that the ‘reaction was faster’ or that ‘the time would be less’ are both insufficient explanations as to why it would be difficult to measure the reaction time accurately.

Question 4

Candidates found this question challenging.

Hydrochloric acid was often correctly identified by addition of magnesium accompanied by a satisfactory observation.

Many attempted to identify sodium sulfite by adding nitric (or hydrochloric) acid. In such cases, it was necessary to **name** sulfur dioxide as a product. The question states that ‘**no other chemicals’** can be used, including those required to test for the presence of sulfur dioxide.

In order to test for the sulfite ion in sodium sulfite acidification with nitric acid is essential.

Question 5

(a) This question was answered very well by almost all of the candidates.

(b) (i) There was a wide variety of responses to this question. Some vague responses were seen, such as ‘a large amount’. Better responses stated more than enough to react with all the iron’..

(ii) Many candidates named an appropriate protective item. ‘Googles’ was seen more often than ‘goggles’. The substance that caused the hazard and the nature of the hazard were usually absent. There was no requirement to handle a hot beaker, thus wearing gloves to avoid this problem is unnecessary.

(iii) Shaking or stirring were rarely mentioned. The sample was already powdered, as seen in the opening sentence, and the beaker is already being heated. Unless candidates are aware of a suitable catalyst for this reaction, suggestion of a catalyst is inadvisable. Increasing the pressure only increases the rate of a reaction involving gaseous reactants.

(c) (i) This question was answered very well. Decanting had to be preceded by allowing to stand and settle. Distillation was occasionally given as a wrong answer.

(ii) Very few candidates were aware of this technique. Only a small number of candidates seemed to know what the question was asking. When a substance is poured from one piece of glassware to another, it is inevitable that a small amount of the substance remains in the first piece of glassware. In this case, the problem can be avoided by washing out the beaker with water, preferably distilled or de-ionised, and transferring the washings into the volumetric flask. This should then be repeated as least once. Dilution has no effect on any quantitative analysis carried out on the solution.

(d) (i) This question was answered very well by almost all of the candidates. A very small number read the burettes upside down i.e.

1	2	3
26.4	29.8	37.7
	4.5	12.6

The use of 0 instead of 0.0 was quite common.

(ii) Many candidates mentioned that there would be a loss of accuracy if 250 cm^3 was used. The many other problems were usually not identified.

(e) to **(h)** These question parts were answered very well by the majority of candidates.

(i) If candidates arrive at an answer which is greater than 100%, they should realise that it is necessary to go back to previous parts and find out where the error is.

Question 6

(a) Candidates had to state that the solution was not a **compound** or did not contain an **ion** of either transition **elements** or transition **metals**. One of the key words was often missing. This was generally answered incorrectly compared to the other parts of **Question 6**.

(b) This question was answered well by many candidates. The main error was that ammonia gas was often not identified even though a positive test was given. Some candidates said that damp red litmus turned blue without saying that a gas was responsible for this.

(c) This question was answered well by a large number of candidates.

(d) This question was answered well by many candidates. A small number of candidates gave a test for chlorine.

Question 7

(a) Candidates were required to give a comparison involving a burette and measuring cylinder. It was common to see that burettes were accurate as opposed to more accurate than measuring cylinders.

(b) There was no need to carry out further experiments as the amount of precipitate had reached the maximum value when 8.0 cm^3 of **H** was added. Many reasons other than this were seen.

(c) The graph was usually well drawn. The two lines were occasionally joined using a curve instead of two intersecting straight lines as required.

(d) (i) This was answered quite well. 10.3 was occasionally seen as an answer instead of 13.0 due to misreading the scale.

(ii) This was answered quite well. 5.2 was occasionally seen as an answer instead of 5.4 due to misreading the scale.

(iii) This was answered quite well. The value of 26.0 was occasionally seen as an answer. This was the height of the precipitate as opposed to the volume. 14.5 was also seen occasionally.

(e) A minority of candidates gained full marks for this question. Some used the mole ratio in the equation incorrectly. Many candidates did not set out their answers in a clear and coherent way. Some did not attempt the calculation.