CHEMISTRY

Paper 5070/11
Multiple Choice

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

General comments

Items which candidates found straightforward were **Question 1**, **Question 8**, **Question 13**, **Question 25**, **Question 30**, **Question 31** and **Question 32**. Candidates found **Question 35** particularly challenging.

Comments on specific questions

Question 2

A high proportion of candidates incorrectly thought that fractional distillation is used in crystallisation and chose **D** in preference to the key, **B**.

Question 3

B was chosen more frequently than the key, **D**, revealing that these candidates incorrectly thought that aluminium ions are insoluble in excess hydroxide.

Question 5

A was a common choice. Candidates did not take into account the basic nature of the drying agent.

Question 6

C was chosen more than the key, **B**, revealing a misunderstanding of metallic bonding.

Question 9

C and **D** were common incorrect answers. Candidates who chose **C** used the M_r of ammonia rather than $2 \times M_r$ from the stoichiometry. Candidates who chose **D** may have assumed 60 kg of N_2 was used.

Question 11

B and **C** were common incorrect answers. Candidates had a weak understanding of what changes occur to electrolytes during electrolysis.

Question 15

C was a common incorrect answer. Candidates had correctly worked out the temperature difference, but not the stoichiometry of the reaction.

Question 27

Many candidates did not know how the position of a metal in the reactivity series related to its stability as a carbonate. Many chose the least reactive metal (carbonate).

Question 28

A was a common answer. These candidates chose a method that is not used for the extraction of tin from its ores.

Question 29

D was a common answer. These candidates had correctly identified electrode oxidation in the electrolysis of aluminium oxide, but it is the anode, not the cathode, which is oxidised.

Question 34

A was a common answer. These candidates incorrectly thought that bromine is added to one C atom rather than across the double bond.

Question 35

This item required candidates to work out that C_4 can have one unbranched and one branched isomer. They then had to work out that each isomer had two different positions for the alcohol group. This proved to be difficult for some candidates.

Question 37

D was a common answer. These candidates had the correct stoichiometry but incorrectly thought that propanoic acid is C_3H_7COOH.

Question 40

C was a common incorrect answer. These candidates incorrectly thought that bromine can react with poly(ethene)

CHEMISTRY

Paper 5070/12
Multiple Choice

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

General comments

Items which candidates found straightforward were **Question 15** and **Question 25.** Items which candidates found particularly challenging were **Question 1**, **Question 6**, **Question 23**, **Question 25** and **Question 30.**

Comments on specific questions

Question 2

B and **C** were common incorrect answers. Candidates who chose **C** did not work out that the salt formed was soluble from the diagrams.

Question 5

A, dry air, and **D**, petrol (gasoline), were common incorrect answers from candidates who thought they were pure compounds.

Question 8

C was a common choice, which shows misunderstanding of how ionic compounds conduct electricity.

Question 9

C and **D** were common incorrect answers. Candidates who chose **C** used the M_r of ammonia rather than $2 \times M_r$ from the stoichiometry. Candidates who chose **D** may have assumed 60 kg of N_2 was used.

Question 10

D was a common incorrect answer. These candidates did not appreciate the difference between number of moles and mass.

Question 12

B and **D** were common incorrect answers. These were the two least reactive metals and as such the least likely to be extracted by electrolysis.

Question 14

Most candidates deduced the reaction was endothermic. Those choosing **B**, a common incorrect answer, did not link this to the temperature of water decreasing.

Question 17

A was chosen more than the key, **C**. These candidates incorrectly thought that catalysts provide reactant particles with more energy.

Question 23

A was a common answer. These candidates incorrectly thought that helium has eight electrons in its outer shell.

Question 24

Many candidates were unable to deduce that X must be a transition metal and/or that X^{2+} had been reduced.

Question 26

Many candidates did not know the position in the reactivity series of carbon and hydrogen in relation to the four metals.

Question 27

Many candidates did not know how the position of a metal in the reactivity series related to its stability as a carbonate. Many chose the least reactive metal (carbonate).

Question 30

Many candidates did not understand that there are no iron(II) or iron(III) ions in molten iron.

Question 31

A was chosen more than the key, **D**. These candidates incorrectly thought that CO is reduced by catalytic converters.

Question 38

Less than half of candidates were able to identify an alcohol from an ether, a carboxylic acid and a ketone.

CHEMISTRY

Paper 5070/21
Theory

Key messages

- It is important that candidates show all relevant working out when completing calculations so that error carried forward can be applied where appropriate. Candidates must also take care to quote their answers to the appropriate number of significant figures.
- Candidates must not confuse ideas about chemical equilibria and rate of reaction. They should not use collision theory when answering questions about chemical equilibria. Candidates must keep ideas about chemical equilibria and rate of reaction separate. Collision theory only applies to questions about rates of reaction.
- Candidates often struggled when balancing equations because they used incorrect formulae. Candidates must recognise which elements have diatomic molecules and for which elements it is appropriate to use the atomic symbol in an equation. Candidates found ionic equations more difficult to balance than 'molecular' equations.
- Correct terminology is important when answering free response type questions, for example when describing global warming, ozone depletion and structure and bonding.

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.

Candidates need to be careful to answer all the question parts and not leave some blank.

Most candidates chose **Questions 6, 7** and **8** in **Section B** and did not attempt **Question 9**.

Comments on specific questions

Section A

Question 1

This question was about elements in the Periodic Table.

(a) Many candidates recognised that a phosphorus atom forms a stable ion by gaining three electrons. Some candidates gave the formula for the phosphide ion, P^{3-}. The most common incorrect answers were vanadium and aluminium.

(b) Many candidates recognised that iron is extracted from haematite.

(c) Many candidates recognised that iron forms an ion that in aqueous solution gives a red-brown precipitate with aqueous ammonia. Some candidates gave the correct formula for the ion, Fe^{3+}, and this was given credit.

(d) Many candidates identified magnesium as the element with similar chemical properties to calcium.

(e) Candidates found this question challenging and often chose silicon rather than carbon.

Question 2

This question was about sodium and its compounds.

(a) The best responses compared the physical properties of sodium with those of typical metals, for example stating that sodium was softer than most other metals. Candidates often recognised that sodium had a low melting point, boiling point and density. A small proportion of the candidates appreciated that sodium was not sonorous. A common misconception was that sodium was a poor conductor of electricity or heat. Some candidates could not distinguish between physical and chemical properties and mentioned the violent reaction between sodium and water.

(b) Many candidates could complete the electronic configuration of sodium.

(c) The best responses gave clear working out and quoted the correct answer of 0.575 g. These answers typically showed the calculation of the moles of hydrogen made, then the moles of sodium needed and finally the mass of sodium. A common error was to use the mass of hydrogen as though it was the amount in moles rather than using the molar volume of hydrogen. A small but significant proportion of the candidates did not attempt this question.

(d) Candidates often gave good explanations about the formation of sodium oxide. Most candidates appreciated that two sodium atoms were needed to provide the two electrons that an oxygen atom needed. Typically, candidates used the correct particles in their answers and did not have ions losing or gaining electrons. A small proportion of the candidates mentioned that the electrons were shared which gained no credit. Some other candidates described the movement of electrons in the wrong direction from oxygen to sodium. Another misconception was to give an answer based on rate of reactions and collisions involving electrons.

(e) (i) Candidates were often able to give a physical property of sodium chloride and typically gave high melting point or conducts electricity when molten or aqueous. Some candidates mentioned that sodium chloride did not conduct electricity and needed to make it clear they were describing solid sodium chloride to gain credit.

(ii) Candidates found this question quite demanding and often only gave one of the electrolysis products. Other candidates gave equations for the electrode reactions and these were given credit if they made the correct products.

(iii) Many candidates confused the test for chloride with the test for chlorine and as a result many answers mentioned damp litmus paper being bleached. Candidates who correctly used silver nitrate almost always included an acid; some included hydrochloric acid rather than nitric acid.

Question 3

This question used aspects of copper compounds to examine fractional distillation and empirical formula calculations.

(a) Many candidates drew a diagram to show simple distillation. These diagrams sometimes included a fractionating column but often this was missed out. Some of the diagrams had an open end by the still head but almost all clearly showed a condenser. Candidates could be awarded credit from diagrams drawn when these were to be annotated. Candidates appreciated that the aqueous solution had to be heated and that the steam was condensed into water by the condenser. A small proportion of the candidates misinterpreted the question and focused on obtaining copper sulfate rather than water. These candidates often just heated the aqueous copper sulfate in an open container, such as a crucible.

(b) Candidates often identified filtration as the separation technique. A common misconception was to use distillation.

(c) Many candidates could complete the empirical formula calculation to obtain $CuCsCl_3$. The most common errors were to use the atomic number rather than the relative atomic mass when calculating the molar ratio, or to use an incorrect relative atomic mass for example carbon instead of copper.

Question 4

This question was about compounds that contain chlorine.

(a) Candidates found this question extremely demanding and often gave answers that suggested they did not realise they had to describe a way to determine the concentration of hydrochloric acid. Often the candidates were still describing a reaction between hydrochloric acid and methanol. Only a few candidates appreciated that the acid should be titrated against a standard solution of an alkali such as sodium hydroxide. Many candidates used a titration against methanol assuming it was an alkali. A significant proportion of the candidates did not attempt this question.

(b) (i) Most candidates could interpret the graph and get 1.38 mol / dm^3.

(ii) Candidates often recognised that the reaction was fastest at point **A** but did not use information from the graph to justify their answer. Many explanations focused on collision theory rather than the gradient of the graph. Some candidates did appreciate they needed to compare the gradients at points **A**, **B**, **C** and **D** but still gave the incorrect answer typically either **B** or **D**.

(c) Most candidates appreciated that the rate of reaction would decrease, however, they found the full explanation more difficult. Many candidates appreciated that the particles have less energy or moved slower. Some candidates did not specify it was less kinetic energy and so were not awarded this mark. Some candidates explained that the collisions were less successful, however, those candidates that mentioned successive collision were not awarded this mark. The last marking point needed a reference to the lower collision frequency and candidates needed to be precise when describing this idea and not refer to less chance of a collision.

(d) Most candidates could describe the correct colour of universal indicator paper. Since the concentration of the hydrochloric acid was not defined in the question any colour that represents a pH of 6 or below was allowed.

(e) Some candidates appreciated that silver chloride and lead chloride were insoluble in water. Many other soluble chlorides were listed by the candidates.

(f) Since CFCs both deplete the ozone layer and are greenhouse gases candidates could describe either problem. Many candidates described both problems and often mixed up their ideas and linked ozone depletion with global warming rather than an increase in the amount of ultraviolet light reaching the Earth's surface.

Question 5

This question was about the properties of Group VII elements.

(a) (i) Candidates had little difficulty using the data provided to make two predictions. A significant proportion of the candidates left the table blank possibly because they did not recognise it as a question.

(ii) Most candidates described astatine as black. A small proportion of the candidates gave blue-black, which was not awarded credit.

(b) Most candidates recalled that chlorine kills bacteria or microbes.

(c) (i) Candidates found this ionic equation very difficult. Many candidates gave equations without ions and others used incorrect formulae such as Cl_2^- or 2I.

(ii) Some candidates could explain that iodine was less reactive than chlorine. Many candidates compared the reactivity with potassium. Other candidates compared the reactivity of the halide ions.

(d) Candidates often gave the answer of 6 sometimes with no real supporting calculations. Candidates who did not get the correct answer often used the incorrect method or did not appreciate they had to work out the relative formula mass of $NiCl_2$. There was very little evidence from candidates who did not get the correct answer of the significance of dividing a number by 18 to get a value of x.

Section B

Question 6

This question was about weak acids.

(a) Most candidates could recall the definition of weak in weak acids. A very small proportion of the candidates referred to partially dissolving rather than partially dissociated.

(b) The idea that the particles were in a lattice or an ordered pattern was well understood and most candidates described that the particles had vibrational motion rather than translational, typically stating that the particles vibrated about a fixed point.

(c) Many candidates deduced that ethanoic acid was a gas, but they did not always use the value of the temperature 130 °C and the boiling point to explain why. The best answers stated that 130 °C was above the boiling point.

(d) The best answers were well organised with a calculation that showed that the amount of ethanoic acid was 0.056 mol and used this value to deduce that the amount of sodium carbonate must have been 0.028 mol. These candidates then compared this value with the amount of sodium carbonate added, which was 0.030 mol or they calculated the mass of 0.028 g of sodium carbonate to show that this was less than 3.18 g. A common misconception was to leave out the use of the mole ratio of ethanoic acid to sodium carbonate and to state that the amount of sodium carbonate was 0.056 mol. A significant proportion of the candidates did not attempt this question.

(e) Candidates found this question challenging and they were rarely able to write the formula for calcium ethanoate.

(f) (i) Candidates often gave the correct name of the ester but there was a significant proportion that gave ethyl butanoate instead.

(ii) Almost all the candidates who answered the question drew a displayed formula showing all of the atoms and all of the bonds; a condensed structure such as $CH_3COOC_4H_9$ would have been sufficient to gain credit. A significant proportion of the candidates did not know how to draw the ester linkage; some drew hydroxy ketones, some just ketones and others with an O—O bond linkage. A significant proportion of the candidates did not attempt this question.

Question 7

This reaction focused on the reaction between steam and carbon monoxide.

(a) (i) The best responses appreciated that the position of equilibrium moves to the right because the forward reaction is exothermic. Candidates who stated the position of equilibrium moves to the left gained no credit for this question. Other candidates focused on the rate of reaction and collisions to explain the shift of position.

(ii) The idea that the number of moles of reactants was equal to the number of moles of product was well understood. Many candidates did not refer to gas in their answer, which in the example in this question did not matter since all reactants and products were gases. In other examples, candidates would be advised to refer to the moles of gas rather than just moles.

(b) (i) Candidates often drew an energy profile diagram for an exothermic reaction rather than for an endothermic reaction. For endothermic processes, candidates would be advised to draw an upward arrow and in the case of an exothermic processes, the change should be drawn with a downward arrow. Some candidates did not label the lines or left the labels in ambiguous places so it was not clear what the label was labelling. A significant proportion of the candidates did not attempt this question.

(ii) Many candidates could balance the equation; others used the wrong number in front of H_2O.

(c) (i) Candidates often gave imprecise descriptions of the formation of sulfur dioxide. The role of sulfur dioxide, as the combustion product when the sulfur impurities combust and in subsequent reactions with oxygen and water, was not well understood. A common misconception was to mention that sulfur condensed in air to make acid rain.

(ii) Candidates often described that acid rain corroded buildings. Some candidates gave more detail in terms of reaction with limestone buildings.

Question 8

This question was about silicon.

(a) Candidates had little difficulty deducing the number of each sub-atomic particle within the isotope of silicon.

(b) Candidates often wrote a balanced equation but used incorrect formulae. Some candidates gave silicon as a triatomic molecule and others gave nitrogen as monatomic. Credit was only awarded for a balanced equation with the correct formulae.

(c) (i) Candidates often gave two similarities between the structures, typically they had giant structure with covalent bonding. Other candidates mentioned the tetrahedral arrangement around some of the atoms. A common misconception was to describe the similarity in physical properties rather than the actual structure and bonding.

(ii) Many candidates did not mention that there are many strong bonds that had to be broken. It was not sufficient just to mention a giant covalent structure. The best responses went on to explain that breaking these bonds would need lots of energy. References to needing more energy to break the bonds were too vague, as they did not make it clear that this would necessarily be a large amount of energy. A significant proportion of candidates referred to the presence of strong or many intermolecular forces; responses such as these were given no credit for this question.

(d) Some candidates could write the molecular formula as $C_4H_{12}SiO_2$. It did not matter what order the atoms were written. A common misconception was to include some structure into the molecular formula such as $C_4H_{10}Si(OH)_2$, this is incorrect since it is not a molecular formula.

(e) Candidates often drew the correct dot-and-cross diagram, but some forgot to draw the outer shell electrons of chlorine which was also required.

Question 9

This question about polymers was the least popular and was often the question that was not answered.

(a) The best responses described the formation of a small molecule as a by-product. Candidates often used the context of a condensation polymer to illustrate their answer.

(b) (i) Candidates often put a circle around one or more of the ester linkages, but a significant proportion of the candidates seemed to not notice the question and left it blank.

(ii) Candidates found this question challenging and rarely drew a diol and a dicarboxylic acid. Candidates either left the question blank or had structures that were still linked together.

(iii) The uses for *Terylene* were well known.

(c) Many candidates did not seem to understand what was being asked in this question and gave vague and imprecise answers that did not indicate the type of linkages that could be formed and why they could be formed. Many candidates did not recognise the amine group and often called it an amide. A significant proportion of the candidates did not attempt this question.

(d) (i) Candidates could often recall the formula for ethene. A small proportion of the candidates did not attempt this question.

(ii) The term *non-biodegradable* was well understood by many candidates and typical responses referred to polymers that could not be broken down by bacterial action. Some candidates referred to polymers that could or could not be recycled.

(iii) Candidates referred to many different pollution problems.

CHEMISTRY

Paper 5070/22
Theory

Key messages

- Many candidates need more practice in interpreting the stem of a question.
- Many candidates need more practice in writing with precision, especially when dealing with redox reactions and equilibrium.
- Some candidates need more practice in organic chemistry, especially in terms of the structure of carboxylic acids and the chemistry of 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. Others did not appear to read the stem of the question carefully enough. For example, in **Question 2(c)(ii)**, some candidates did not take sufficient notice of the instructions to consider 'one other physical property'. In **Question 5(c)**, many candidates did not take notice of the instruction to 'answer in terms of ease of formation of ions'. In **Question 7(e)**, many gave a laboratory or minor use of sulfuric acid rather than a 'major use'.

Some candidates were able to write precise answers using appropriate scientific vocabulary. Others needed further practice in writing with precision, especially when dealing with redox reactions and equilibrium. In **Question 2(c)(i)**, many candidates did not distinguish between atoms and ions. In **Question 6(b)**, some candidates wrote vague statements about the movement and arrangement of particles in a liquid, often referring to the proximity of the particles as well. In **Question 7(b)(i)** and **7(b)(ii)**, many candidates did not specify the left or right of the equation or the forward or backward reaction in the appropriate place. This resulted in confused answers. In **Question 8(e)**, many candidates did not make a clear distinction between copper ions and copper atoms in the redox equation. In this sort of question, candidates should be advised to write the formula of the species rather than the name to avoid confusion about the species being referred to.

Some candidates needed more practice in writing answers to extended questions. Those who answered these questions using bullet they came to them. In **Question 3(a)**, those candidates who wrote about the fractional distillation in a logical order tended to be more successful than those who wrote a series of unordered statements. In addition, where there is an opportunity to draw a labelled diagram as well as extended writing, candidates who drew a neat well-labelled diagram, generally performed. In **Question 4(c)**, many candidates wrote explanations about rate of reaction but did not refer to the effect of particle size and temperature on rate, e.g. rate increases/decreases.

The writing of balanced equations was not always successful. Most candidates needed further practice in the construction of ionic equations, as exemplified by **Question 2(e)(i)**. Candidates were not confident in identifying the species involved and also could not balance the equation. In **Question 6(e)**, many candidates needed more practice in balancing equations involving the reactions of carboxylic acids with metals.

Practical aspects of chemistry, such as **Question A4(a)**, about describing the methods for following the progress of a reaction, posed a challenge for some candidates. Others needed further practice in questions about chromatography, such as **Question 9(e)**, especially relating to the calculation of R_f values.

Some candidates needed more practice in aspects of polymer chemistry, especially when drawing a section of a condensation polymer chain from a given monomer in **Question 9(c)**. Others needed further practice in writing the displayed formula and molecular formula of compounds in **Questions 6(a)** and **8(c)**.

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 refers to. Others needed more practice in questions involving the application of the correct number of significant figures in **Question 4(d)** or the appropriate use of stoichiometry in **Question 6(d)**.

Comments on specific questions

Section A

Question 1

This was the best answered of all the questions in the paper. Many candidates performed well in each part. The exceptions were in **(b)**, where many selected other gases rather than chlorine and in **(d)**, where many candidates chose solids other than aluminium as being suitable for use as food containers.

(a) Most candidates correctly chose a Group 6 element and some gave all three from the table. The commonest error was to choose an element from Group 7.

(b) Some candidates recognised that chlorine is a light green gas. Others gave the names or other gases in the table; fluorine being the commonest error. A minority chose solids such as silicon or arsenic.

(c) Many candidates recognised that iodide ions give a yellow precipitate with silver nitrate. The main incorrect response was sulfur, presumably because candidates knew that it was a yellow solid.

(d) Many candidates identified the use of aluminium in food containers. A significant minority responded with the incorrect response of either carbon or silicon. A few appeared to guess and chose gases such as argon.

(e) This was the best answered part of **Question 1** with most candidates recognising that nitrogen forms 78% of dry air. The commonest error was to suggest oxygen. A significant minority chose argon.

Question 2

Parts **(a)** and **(b)** of this question were well answered. In **(c)(i)**, many candidates needed more practice in writing clearly. Many did not make it clear whether they were referring to atoms or ions. In **(c)(ii)**, others needed to revise the physical properties of ionic compounds. In **(d)**, many candidates also needed to revise the electrolysis of aqueous solutions and how to construct ionic equations in **(e)(i)**.

(a) Many candidates were able to state two properties characteristic of most metals. The commonest incorrect responses involved reference to properties typical of only transition metals, such as high density, high strength or hardness.

(b) Most candidates were able to complete the electronic configuration of magnesium correctly. The commonest errors were either to include an extra electron shell or draw more than two electrons in the outer shell. A few candidates drew the structure of a magnesium ion rather than a magnesium atom.

(c) (i) Some candidates referred to the sharing of electrons between the atoms rather than the transfer of electrons from the magnesium atom to the bromine atoms. Others implied that the electrons were transferred from the ions rather than the atoms. It was incorrect to refer to electron transfer from a magnesium atom to a bromide ion. Others omitted to mention the number of electrons transferred.

(ii) Some candidates suggested a suitable physical property for an ionic compound. The commonest correct answer was to suggest high melting point or high boiling point. Many candidates who chose to write about electrical conductivity did not qualify their answers with the state. Others did not gain credit because they ignored 'one other' in the stem of the question and chose solubility in water. A considerable minority of candidates suggested chemical properties rather than physical properties.

(d) A minority of candidates gave a fully correct answer of bromine at the anode and hydrogen at the cathode. The commonest errors were to reverse the anode and cathode products; to suggest the formation of magnesium or water at the cathode; to suggest oxygen at the anode or to give the formulae of ions rather than elements. Some candidates responded with half equations, some of which were correct and others incorrect. A significant minority of the candidates gave products that bore no relationship to the ions present in solution, e.g. lead or chlorine.

(e)(i) This was the least well answered part of **Question 2**. Magnesium metal featured, incorrectly, in many of the responses. When present, the ions were often given incorrect charges or species such as Mg^+Br or $MgClBr^+$ were written. Other candidates wrote the correct species, but the equation was not balanced. Another common error was to write halide ions with either a positive charge or as Br_2^- or Cl_2^-.

(ii) Some candidates appreciated that the comparison should be between the reactivity of chlorine and bromine. Many candidate made a comparison using one or more of the ions. Others had comparisons including the reactivity of magnesium.

Question 3

This question was generally well answered. Many candidates gave good answers to **(a)** and **(c)**. In answering questions involving diagrams as well as written material, such as **(a)** candidates should be encouraged to draw a well labelled diagram. In **(b)**, others needed more practice in memorising the uses of petroleum fractions and in explaining how carbon monoxide is formed and its effect on human health in **(d)**.

(a) Many candidates drew a sufficiently good, labelled diagram or gave sufficient written information to gain partial credit. The commonest errors were to suggest that the separation of the petroleum fraction is based on melting points or density. Some candidates drew diagrams of laboratory apparatus instead of a fractionation column in an oil refinery. Others drew diagrams of the column with the correct fractions in order but omitted the idea of heating and different boiling points. Many candidates did not show where petroleum entered the column or where the fractions left the column because they drew the arrows in the wrong direction. A significant minority of the candidates confused the fractionation process with the extraction of iron in a blast furnace. Candidates who drew a well labelled diagram, generally performed well. Those who only gave a written answer often wrote contradictory or vague statements.

(b) Some candidates gave correct uses of the kerosene and/or naphtha fractions. The most common incorrect answers for kerosene involved writing answers which were not specific enough, e.g. cars, fuels. The commonest incorrect answers for naphtha included: road surfacing; waxes; plastics or livestock.

(c) (i) Most candidates identified methane, ethane and propane as alkanes. The commonest error was to suggest alkenes. A few candidates suggested alcohols or carboxylic acid.

(ii) A majority of the candidates knew the correct general formula for the alkanes. The commonest errors were C_nH_{2n} or C_nH_{2n+1}.

(d) (i) Some candidates focused correctly on the idea of incomplete combustion or insufficient oxygen. Others suggested that oxygen was not present at all. Other common errors included carbon reacting with carbon dioxide to make carbon monoxide or combustion unqualified.

(ii) The commonest correct answers focused on the toxic nature of carbon monoxide or preventing the blood from carrying oxygen. Others wrote biological answers that did not go far enough to answer the question, e.g. 'carbon monoxide reacts with haemoglobin'. Mention of lung cancer, lung diseases and breathing problems were not sufficient to gain credit.

Question 4

Some candidates answered this question well. The test for carbon dioxide was well known in **(e)** and many candidates were able to explain the effect of particle size on rate of reaction in **(b)**. Other candidates needed more experience in practical-orientated questions such as in **(a)** and in calculations and the use of significant figures such as in **(d)**.

(a) Some candidates showed their experimental experience by writing good answers, indicating how the volume of the gas collected was to be measured and also indicating that the time should be measured at specific intervals. Others responded as if it the question was how to increase the rate, e.g. by increasing the temperature by adding thermal energy (rather than measuring the temperature increase of an exothermic reaction). A minority of the candidates thought that the increase in mass of products was a suitable alternative. Although the method of counting bubbles was accepted as an alternative method in this case, candidates should be discouraged from using this method, since bubbles may be of different sizes depending on where they are released from the surface of the solid.

(b) Some candidates gave good answers referring to greater surface area or more particles exposed, as well as increased collision frequency. Others did not refer to the rate or frequency of collisions and only 'more collisions', which was not sufficient. Many candidates incorrectly thought that smaller particles would have a smaller total surface area for the same mass of substance. A few candidates disadvantaged themselves by omitting the effect on the rate of reaction. A greater number disadvantaged themselves by suggesting that the particles would have more kinetic energy.

(c) The best responses suggested that the kinetic energy of the particles increases and that there are a greater number of particles with energy above the activation energy as well as the collision frequency increasing, which is a less important point. The commonest errors were to write about more energy rather than more kinetic energy and more collisions rather than more frequent collisions.

(d) Some candidates gave the answer to three significant figures. Most candidates just gave the answer to one significant figure. The commonest error was not to use the value of 24 000 for the number of cm^3 in a mole of gas. Many did what they thought were mole calculations for calcium carbonate but used the molar mass of carbon dioxide instead.

(e) The limewater test for carbon dioxide was very well known. The most common error was to suggest the extinction of a lighted splint. This was not accepted, as although carbon dioxide will do this, so do several other gases.

(f) Many candidates realised that calcium hydroxide neutralises acidic soil. Fewer mentioned that calcium hydroxide is basic or alkaline. A small proportion of the candidates suggested, incorrectly, that calcium hydroxide reduces or lowers the pH.

Question 5

Some candidates answered this question well and a majority were able to use the information in the table in **(a)(i)** to deduce the values of the melting point and atomic radius. Many candidates were able to do the calculation in **(d)**. Others made simple mathematical errors. Most candidates needed further practice in reading the stem of a question carefully. This was shown by the large number of candidates who in **(c)** did not refer to the formation of ions. Some candidates needed more experience in balancing equation in **(b)(i)** and in understanding which oxides are basic and which are acidic in **(b)(ii)**.

(a) (i) Most candidates deduced the melting point and atomic radius correctly.

(ii) The best answers suggested that there is no trend in the values or that the values go up and down. Incorrect responses tended to be about the high reactivity of potassium. Vague answers such as 'irregular', 'not constant' or 'varies' were not accepted because they could still refer to an upward or downward trend.

(b) (i) Some candidates were able to balance the equation for the reaction of sodium with oxygen. Others made errors such as writing the formula of oxygen as O rather than O_2 or writing the formula of sodium as Na_2. The commonest error in balancing the equation was to put 2Na on the left instead of 4Na.

(ii) The best answers referred to the idea that basic oxides, e.g. sodium oxide contained a metal. A wide variety of incorrect responses was seen. These included the suggestion that sodium oxide is an acidic oxide or just a metallic oxide, without reference to it being a basic oxide, or trying to relate basicity with the reaction of sodium with water.

(c) Most candidates ignored the instruction to base the answer around ease of formation of ions and simply stated that sodium was more reactive than copper.

(d) Many candidates were able to calculate the number of moles of water of crystallisation correctly. The commonest error was to calculate the relative mass of the iodate with one water molecule, i.e. 216. Others subtracted 216 from 288 to give the common incorrect answer of 72 or then divided this by 18 to give an incorrect answer of 4. A minority used a correct molar mass of water (16 rather than 18).

Section B

Question 6

A few candidates gave good answers to many parts of this question. Many did not perform well in comparison to the questions in ***Section A*** of the paper. Many candidates needed to revise organic structures and formulae especially of carboxylic acids and their salts in **(a)** and **(e)**. In **(c)**, many candidates wrote vague or incomplete statements to explain the state of butanoic acid at –4 °C. In **(f)**, many did not answer the question fully. Parts **(b)** and **(d)** were better done, although a significant number of candidates did not give precise enough answers to gain credit.

(a) Some candidates were able to draw the correct structure of butanoic acid. A few candidates got the formula correct but drew –OH in the structure rather than –O–H. Others either did not respond or drew –OH or –O bonds coming from the middle of the carbon chain.

(b) The commonest errors arose through imprecise writing. For movement, many wrote about arrangement of atoms or proximity of the particles in either movement or arrangement. Very often the movement was implied by terms such as 'vibrate' or 'rotate'; these did not go as far enough as to suggest movement from place to place.

(c) The best answers included the term 'liquid' as well as some idea that the temperature given was above the melting point and below the boiling point. The state chosen was sometimes incorrect; both solid and gas being not infrequently seen. The commonest error was to focus on only one change of state, usually melting, e.g. 'it is liquid because the temperature is above the melting point'. Imprecision of writing was one of the main problems in candidates' explanations.

(d) Many candidates calculated the number of moles of sodium carbonate and butanoic acid moles correctly but did not carry out the third step. The best answers included an accurate explanation of the third step in terms of multiplying the moles of sodium carbonate by two or dividing the moles of butanoic acid by two. Common errors included working entirely in grams rather than moles or suggesting that butanoic acid is in excess because 0.06 moles of butanoic acid is greater than 0.028 moles of sodium carbonate. These responses did not take into account the stoichiometry of the equation.

(e) A minority candidates were able to construct the equation. The correct formula of magnesium butanoate was rarely seen and even when it was, the balance with two moles of butanoic acid was sometimes missing. The commonest errors with the formula for magnesium butanoate were $(C_3H_7COOH)_2Mg$ and C_3H_7COOMg.

(f) The best answers included a comparison of the colour with a Universal Indicator colour chart. Litmus and methyl orange were often seen in place of Universal Indicator. Candidates often described the colours obtained with Universal Indicator rather than a comparison of the colour with a colour chart.

Question 7

This question was generally well answered. Many candidates could draw good energy profile diagrams in **(c)** as well as give a suitable use for sulfuric acid in **(e)**. Some candidates identified vanadium(V) oxide catalyst in **(a)** and selected a suitable raw material for the manufacture of sulfuric acid in **(d)**. Others did not gain credit in **(d)** through not reading the stem of the question carefully enough. The equilibrium questions in **(b)** were the least well done. Many candidates were not specific enough in their answers.

(a) Many candidates identified vanadium(V) oxide as the catalyst in the Contact process. The main omission was the missing or incorrect oxidation number of the vanadium(V) oxide. The main errors were to suggest nickel, platinum or iron.

(b) (i) Some candidates wrote vague statements about which reaction they were referring to. Candidates must be careful about the link between the direction of the reaction and whether this is exothermic or endothermic. The best answers wrote about the forward reaction being exothermic or the backward reaction endothermic. A considerable number of candidates responded with ideas about rate of reaction rather than equilibrium position.

(ii) As in **(b)(i)**, many candidates wrote vague statements about the link between the direction of the reaction and the number of the moles and did not make it absolutely clear whether there were more moles of gas on the left than on the right. Some candidates responded with ideas about rate of reaction rather than equilibrium position. Candidates should be reminded that it is important to refer to the number of moles of gas when answering this sort of question.

(c) A considerable number of candidates drew diagrams for an endothermic reaction. Others muddled the arrows showing the enthalpy change and activation energy or drew single lines or double-headed arrows to represent the enthalpy change.

(d) Many candidates correctly chose either sulfur or water as raw materials. Others either repeated the stem of the question and suggested air or oxygen, or suggested oxides of sulfur or sulfuric acid.

(e) Many candidates suggested a suitable use for sulfuric acid. The commonest errors were to suggest bleach (unqualified) or cleaning (unqualified). Others suggested various laboratory preparations which cannot be regarded as major uses. A small number of candidates did not give uses and gave sources, e.g. volcanic eruptions or environmental problems, e.g. acid rain.

Question 8

This was the best answered of the ***Section B*** questions. Most candidates were able to deduce the correct number of sub-atomic particles in **(a)(i)** and to balance the equation in **(b)**. Others needed to learn definitions with more precision such as in **(a)(ii)** and to practice writing molecular formulae from a given displayed formula in **(c)**. Most candidates needed to write with greater precision when dealing with questions involving redox such as **(e)**. In this sort of question, candidates should be advised to write the formula of the species rather than the name in order to avoid misinterpretation.

(a) (i) A considerable minority of the candidates gave 31 for the number of protons or electrons. Another common error was to give the neutron number as 15 and the proton number or electron number as 16.

(ii) Some candidates gave good definitions including the essential word 'atoms'. Others referred to isotopes as molecules, elements or substances. Other common errors included reference to relative atomic mass or different numbers of protons.

(b) Most candidates were able to balance the equation. The commonest errors were 3P and the omission of the 3 before P_2O_5.

(c) Some candidates gave the correct molecular formula. Others could count the atoms but did not present the simple molecular formula, writing formulae such as $HPO_3H_2P_2O_7H_3$. The number of oxygen atoms was often miscounted; 13 oxygen atoms being not uncommon.

(d) Many candidates drew a correct dot-and-cross diagram for phosphorus trichloride. Others missed out the lone pair on phosphorus or only had the bond pair on each chlorine atom. A minority of the candidates either placed three electrons in bonding positions or drew structures with only one or two chlorine atoms.

(e) The best answers referred to copper ions gaining electrons. Most candidates referred to copper (on the right hand side of the equation) rather than copper ions (on the left). Candidates were expected to write the precise species rather than just a vague reference to copper. In this sort of question, candidates should be advised to write the formula of the species rather than the name to avoid misinterpretation. Many explanations were based, incorrectly, on gain of oxygen or loss of hydrogen. Others knew the definition of reduction or an oxidising agent but wrote conflicting statements about losing electrons.

Question 9

This was the least popular of the ***Section B*** questions to be chosen and it was also the least well answered question on the paper, with many candidates omitting to answer **(b)** (hydrolysis of proteins), **(c)** (drawing two repeat units of an amino acid) and **(d)** (recognition of an alternative linkage). Some candidates were able to state the name of a natural polymer in **(a)**; many chose the name of a synthetic polymer such as nylon. The section about chromatography in **(e)** was answered better; many candidates inverted the expression for calculating R_f values in **(e)(iii)**.

(a) Some candidates chose a suitable natural polymer such as starch, cellulose or DNA. The commonest incorrect answer was carbohydrate, which is too general a term. A number of candidates repeated ‘protein’ from the stem of the question and so did not gain credit. A minority of the candidates chose manmade polymers such as nylon.

(b) Very few candidates were able to describe the hydrolysis of proteins. Many just suggested adding water without heating. A minority of the candidates suggested adding oxidising acids. Some candidates stated the addition of suitable enzymes; some of these also suggested the use of high temperatures.

(c) Very few candidates drew two repeat units. The units were often drawn incorrectly often as –COOH–H–NH–. Others either drew two separate units or units which bore very little relationship with the amino acid shown.

(d) A minority of the candidates recognised the ester linkage. Fewer gave a convincing explanation as to how the linkage arose by reaction of the –COOH and –OH groups.

(e) (i) Most candidates gave a suitable explanation as to why the baseline should be drawn in pencil. The commonest errors were to state either that the ink reacts with the solvent or that the pencil will not fade.

(ii) Many candidates responded correctly with the idea that the locating agent makes the spots visible. Common errors included stopping the spots from moving further or vague statements such as ‘to recognise the substance’. Other candidates referred to the solution or the solvent rather than the spots.

(iii) A minority of the candidates calculated the R_f value correctly. The commonest error was to invert the calculation as distance moved by solvent front divided by distance moved by amino acid.

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Paper 5070/31
Practical Test

Key messages

- Candidates are advised to carefully read through a whole question before beginning any experimental work. In **Question 1**, this enables candidates to get a grasp of what is to be done practically and to recognise the purpose of the experiments. In **Question 2**, this provides an opportunity to identify familiar tests and so be prepared for the likely outcomes.

- Success in the quantitative task required candidates to follow instructions involving volume and temperature measurement and to use the data generated to plot a graph. A calculation and questions about the experiment itself followed. The qualitative tests were centred on a metal which reacted with hydrochloric acid and a solution containing a cation and an anion. Candidates competent in carrying out test-tube reactions and the accurate recording of observations performed well.

General comments

Overall, most candidates were able to complete the experiments required to produce all the data for **Question 1**. Many plotted correct graphs but the calculation and practical-based questions proved more challenging.

All the candidates attempted the tests in **Question 2**. There was much variation in the quality and the accuracy of the observations recorded.

Comments on specific questions

Question 1

(a) Most candidates recorded the initial and highest temperatures for all 7 experiments. There were many whose values were not to the appropriate precision e.g. 24.0, 25.5, given the resolution of the thermometers used. Virtually all calculated the temperature rises successfully.

The correct pattern of temperature rises i.e. an increase over the first 3 or 4 experiments followed by little or no change in its value over the remainder, was usually produced. However, some candidates decided that the pattern should involve a decrease in temperature rise following the increase and altered results in order to obtain it.

(b) Plotting the temperature rises associated with the volumes 12, 16 and 18 cm^3 caused difficulties for some. Many accurately plotted all their data. Despite the instruction to draw two intersecting straight lines, a few candidates simply joined the points together. Candidates should aim to draw best-fit straight lines.

(c) Using the volume scale proved problematic for some.

(d) The calculation was properly completed by a number of candidates but not all of these gave the final answer to 2 significant figures as required.

(e) Few noted the importance of using a cup made of plastic; an insulator.

(f) This question proved to be very challenging. Repeating of the experiments was accepted as an answer; it was rare to find improvements such as use a lid, measure the volume of water using a burette or use a more precise thermometer. Descriptions of how to do the experiment correctly, such as how to use a thermometer to avoid parallax error or how to read the scale on a measuring cylinder, are not improvements.

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.

Candidates should make full use of the Qualitative Analysis Notes supplied on the last page of the exam paper.

Test 1

Many noted bubbling and the disappearance of the metal. Some correctly tested the gas with a flame, using a lighted splint, and heard a pop but not all of these named the gas as hydrogen.

Test 2

A white precipitate was reported by many but not all of these stated it was insoluble in excess.

Test 3

With ammonia, magnesium ions produce a white precipitate, which is insoluble in excess. No reaction was allowed as an observation in this test as the small quantity of precipitate produced was difficult to detect.

Test 4

Most reported a brown precipitate on addition of alkali to **S** in **(a)**; the insolubility of the precipitate in excess was not so frequently noted. When hydrogen peroxide is mixed with the alkaline iron(III) hydroxide in **(b)**, the mixture bubbles. Far fewer spotted the bubbling here than in test **1** and only a small number managed to test **and** identify the gas as oxygen.

Test 5

The mixture of solutions turns red-brown in **(a)** as a result of the iodine produced by the reaction of iron(III) ions with iodide ions. Providing the mixture in **(b)** is left to stand after shaking, the immiscible organic liquid forms a layer above the aqueous material and the pink-purple colour of the iodine dissolved in the covalent layer is evident. The latter was noted by few candidates.

Test 6

Many candidates reported a precipitate formed in **(a),** but it was commonly thought to be yellow rather than white. The solid was generally found to remain when nitric acid was added in **(b)**.

Conclusions

Several candidates gave a suggestion consistent with the evidence obtained, for the type of metal **R** is, including an alkaline earth metal, Group **II** metal or a metal like magnesium.

The brown precipitate recorded in test **4(a)** generally led to the identification of iron(III) ions in **S**. The identity of the anion in **S** was less frequently known. Common errors were either to suggest a chloride, despite the precipitate in test **6** not being described as white and insoluble in acid, or another anion was named, often sulfate.

CHEMISTRY

Paper 5070/32
Practical Test

Key messages

- Candidates are advised to carefully read through a whole question before beginning any experimental work. In **Question 1**, this enables candidates to get a grasp of what is to be done practically and to recognise the purpose of the experiments. In **Question 2**, this provides an opportunity to identify familiar tests and so be prepared for the likely outcomes.
- Success in the quantitative task required candidates to follow instructions involving volume and temperature measurement and to use the data generated to plot a graph. A calculation and questions about the experiment itself followed. The qualitative tests were centred on a metal which reacted with hydrochloric acid and a solution containing a cation and an anion. Candidates competent in carrying out test-tube reactions and the accurate recording of observations performed well.

General comments

Overall, most candidates were able to complete the experiments required to produce all the data for **Question 1**. Many plotted correct graphs. The calculation and practical-based questions proved more challenging.

All the candidates attempted the tests in **Question 2**. There was much variation in the quality and the accuracy of the observations recorded.

Comments on specific questions

Question 1

(a) Nearly all the candidates recorded the initial and highest temperatures for the 7 experiments. There were a significant number who did not record the values to the nearest 0.5 °C. A few made subtraction errors in determining the temperature rises, often as a result of altering their original readings.

The correct pattern of temperature rises i.e. an increase over the first 3 or 4 experiments followed by little or no change in the values thereafter, was generally produced. However, some candidates reported that the temperature rises decreased in the later experiments and it appeared that they had changed perfectly good results in order to secure this outcome.

(b) Most plotted the points correctly but there were a number who believed that each small square on the *x*-axis was equivalent to $1.0\,cm^3$ rather than $0.5\,cm^3$. Drawing two intersecting straight lines proved challenging, especially if candidates did not realise that the temperature rises should increase and then level off once sufficient acid had been added to neutralise the alkali.

(c) The volume where their two lines crossed was usually accurately determined.

(d) The calculation was properly completed by a good proportion of candidates but many of these did not give the final answer to 2 significant figures as required.

(e) There was a wide variation in the explanations provided with ‘plastic being unreactive’, the most popular incorrect response.

(f) This question proved to be very challenging. Repeating of the experiments was accepted as an answer; it was rare to find improvements such as use a lid, measure the volume of water using a burette or use a more precise thermometer. Descriptions of how to do the experiment correctly, such as how to use a thermometer to avoid parallax error or how to read the scale on a measuring cylinder, are not improvements.

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.

Candidates should make full use of the Qualitative Analysis Notes supplied on the last page of the exam paper.

Test 1

Many noted the bubbling. Some correctly tested the gas with a flame, using a lighted splint, and heard a pop but not all of these named the gas as hydrogen. Given that **R** is a shiny flexible piece of foil, it is difficult to understand why some candidates tested the gas with damp blue litmus paper or limewater.

Tests 2 and 3

The addition of aqueous sodium hydroxide or ammonia to a solution needs to be done gradually with mixing. In this case, there will be excess acid to remove before any precipitation can take place. Those who were careful in their addition in test **2** reported a white precipitate, which dissolved in excess and a good number of these also noted the final solution was colourless. There were many who missed the solid, either because the alkali was added too quickly or insufficient was added to neutralise the acid.

In test **3** a white solid is formed on addition of sufficient ammonia, which remains in excess.

Test 4

There were fewer candidates who identified ammonia here, than identified hydrogen in test **1**. There was confusion over the use of aluminium and alkali in the test for nitrate ions.

Test 5

Most saw something happened when **R** and **S** were mixed but struggled to record their observations. The solid turning brown or 'rusting' was the more frequently noted point and it was rare to find any reference to the blue colour of the solution being lost.

Test 6

Many reported a precipitate formed, but it was commonly thought to be blue rather than white.

Test 7

The majority recorded that the precipitate remained in acid and at this stage more indicated that the solid was white rather than blue.

Test 8

Most indicated that a dark blue solution was formed on addition of excess ammonia. There were a few who noted the presence of a white or blue solid in the final liquid, presumably because the contents of the test-tube were not properly mixed.

Conclusions

Many sought to identify **R** as aluminium but did not have the evidence to support the claim.

The cation in **S** was correctly identified by the majority of candidates as copper(II). The identity of the anion in **S** was less frequently known. Common errors were either to suggest a chloride, despite the precipitate with silver nitrate not being described as white, or another anion was named, often sulfate.

CHEMISTRY

Paper 5070/41
Alternative to Practical

Key messages

- The planning task is the aspect which candidates find the most difficult. Better performing candidates have a good general understanding of practical techniques, as listed within the syllabus, and a careful reading of the question so that they know what is expected of them.
- Candidates who perform less well tend to describe an experiment with which they are familiar rather than applying general principles to the context set in the question.

General comments

In general, candidates appeared to be familiar with the practical contexts in the questions. Some still appear to be answering from learned knowledge rather than from experience of actually seeing and using apparatus in experiments.

Comments on specific questions

Question 1

(a) Many candidates were familiar with electrolysis and were able to deduce the products formed from the information provided. Candidates were less able to describe the observations at the cathode in sufficient detail. When describing the product from copper sulfate, candidates needed to state both the colour and the state of the copper. For the potassium iodide, candidates needed to describe the observation made when the gas was produced in the solution. Simply stating that a colourless gas was produced was insufficient. Candidates needed to state the observation of bubbling or effervescence.

(b) Most candidates were familiar with the test for oxygen. A few were unclear about the difference between a burning splint and a glowing splint.

Question 2

(a) Candidates often had an idea of what an excess was; they found it more difficult to express their answers to this question clearly. They needed to be able to explain that there was **more** calcium carbonate than was needed to completely react with the hydrochloric acid. It was insufficient to simply state that there was a large amount. There was no need to describe this in terms of moles; although credit was given as long as the answer explained that all of the acid was used up.

(b) Many candidates were familiar with these pieces of apparatus. Some reversed their answers or confused the conical flask with a volumetric flask.

(c) In this question, candidates needed to suggest a piece of apparatus which was capable of maintaining a constant temperature. Just referring to the use of a thermometer was insufficient.

(d) A significant number of candidates did not understand that the question was referring to controlled variables. Suggesting temperature was quite common, even though the question stated that the reaction had been done at different temperatures. Other answers were too vague as they did not refer to the reactant, for example stating 'concentration' rather than 'concentration of the acid'. Mass and volume were also common incorrect answers.

(e) (i) Candidates had to refer to the graph in their answer. Many wrote vague answers that did not make it clear how the fastest reaction is identified. For example, an answer which only referred to the gradient was insufficient rather than stating that the graph with the steepest gradient is the fastest.

(ii) This was quite well answered even by candidates who could not answer **(e)(i)**. Some candidates who answered **(i)** correctly then reversed the answer to **(ii)**. They knew that the steepest gradient was the fastest but could not identify which graph had the steepest gradient.

(iii) Candidates frequently referred to the line becoming straight rather than horizontal. Candidates should also try to avoid the use of terms such as 'they' or 'it' as these can be ambiguous. For example, writing 'it becomes constant' rather than 'the volume (of carbon dioxide) becomes constant'.

(iv) Many candidates missed that the question stated that the calcium carbonate was in excess and suggested that all of the calcium carbonate had been used up. Other candidates simply referred to reactants being used up. The question required candidates to recognise that it was the acid that would have been used up.

Question 3

This question required candidates to plan an experiment. Detailed information was given to the candidates to help them formulate their plan. It was clear from many of the answers that candidates might not have taken the time to carefully read the introductory information before attempting to write their answers. It is worth spending time studying the information to ensure that all points are covered. Some candidates annotated these notes to help them prepare their plan and often performed well.

Common errors included:

- starting with copper oxide on its own, even though they were provided with a mixture
- adding sulfuric acid to the mixture but not doing anything to make the copper oxide react and dissolve
- filtering and carrying out extensive procedures on the filtrate (usually involving crystallisation)
- suggesting heating the *solid* to saturation point
- trying to describe a titration
- describing procedures in the wrong order, for example washing a product after drying it.

Question 4

This question was generally well answered. There were some who did not attempt the question at all. There were no common patterns to the mistakes that candidates made. There was some uncertainty on whether a precipitate was soluble in excess or not.

Question 5

(a) Most candidates referred to accuracy; some did not make it clear which piece of apparatus was the more accurate.

(b) Frequently, measuring cylinders were incorrectly suggested. Other pieces of apparatus which are not used for measurement were also suggested, for example, test-tubes and beakers.

A volumetric flask was also suggested. This is an accurate piece of measuring apparatus. However it would be inappropriate here, because too much liquid would be left in the volumetric flask when its contents are transferred into the conical flask.

(c) Candidates should be aware that during titrations, the last liquid used to wash out the burette (and also the pipette) is the liquid that is being measured. This question tested whether candidates knew why this was the case and needed them to refer to the fact that washing out with water will dilute (slightly) the solution that is being used.

Several candidates incorrectly suggested **L** would react with water.

(d) Candidates were familiar with the recording of results from a titration and knew how to select appropriate values for the calculation of an average. Some candidates did not record values to the appropriate resolution. In particular, 0 was seen a significant number of times rather than 0.0.

(e)–(j) Candidates were generally able to correctly carry out these calculations with just occasional errors. Even when an error was made, candidates were often able to continue with the calculation in a correct manner and were given credit for this.

Question 6

(a) (i) Many candidates recognised this as an exothermic reaction. A significant number did not notice that the original temperature was 22 °C and thought that the reaction itself was causing the temperature to go down and was therefore endothermic.

(ii) Those candidates who recognised the reaction as exothermic were often able to suggest cooling as the cause of the reduction if temperature decreases.

(iii) Many candidates did not refer back to the text to identify room temperature as 22 °C and so the lowest temperature that would be reached by cooling. Incorrect answers appeared quite random with any number below 25 °C being selected.

(b) (i) Candidates were generally able to produce appropriate graphs. Some did not follow the instruction to extend the line to intersect the *y*-axis.

(ii) Candidates who correctly plotted the graph were usually able to identify the anomaly.

(c)(i)(ii) Candidates were mainly able to read correct values from their graphs. Credit was given for correct values based on the line the candidate had drawn.

(d) (i) Candidates who had extended the line to the *y*-axis usually answered this correctly.

(ii) Many candidates did not recognise what was needed to do this simple subtraction.

(e) (i) Many candidates completed this calculation correctly. Those who made mistakes seemed to think they needed to use values from earlier in the question

(ii) A number of candidates substituted correct values into the expression but then were not able to obtain the correct answer.

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Paper 5070/42
Alternative to Practical

Key messages

- It is important to read the questions carefully. For example, in **Question 3**, candidates performed less well by describing irrelevant procedures unrelated to the question.
- Numerical answers in volumetric analysis should be quoted to an appropriate number of significant figures.
- Oxygen can only be formed at the anode(+) during electrolysis. Hydrogen can only be formed at the cathode(–).

Comments on specific questions

Question 1

(a) Very few candidates identified the gas jar. Beaker, measuring cylinder (despite the lack of graduations) and gas cylinder were common answers.

(b) It was reasonably well known that because gas **A** was less dense than air it could be collected in apparatus **Y**, and because it was insoluble in water it could be collected by apparatus **Z**.

(c) It was reasonably well known that because gas **C** was more dense than air and soluble in water it could only be collected in apparatus **X**.

(d) (i) The fact that gas **B** was denser than air was recognised by many candidates. Some candidates referred to the density of gas **B** without making a comparison with the density of air.

(ii) The fact that gas **B** was colourless and therefore it would not be possible to tell when the gas jar was full if **X** was used, was only mentioned by a minority of candidates. Most responses focussed on lack of solubility and density.

Question 2

(a) The majority of candidates identified the conical flask.

(b) Candidates were informed that ‘the student records the mass every 30 seconds’. Therefore, time was the variable that needed to be measured using a suitable device. There was no requirement to measure the volume of the acid the mass of calcium carbonate or the temperature, which were all commonly stated by candidates.

(c) It was important to state that the carbon dioxide produced in the reaction **escaped** as a gas **from** the apparatus, which is why the mass decreased. Some responses mentioned that the acid had escaped from the apparatus by evaporation.

(d) Candidates should be aware that the rate of a reaction depends on the **concentration** of hydrochloric acid and the **temperature** at which the reaction takes place. These factors were mentioned by a minority of candidates.

(e) (i) The question required candidates to 'describe how the graphs are used'. Some candidates answered without reference to the graphs. 'The steeper the graph the faster the rate of reaction', was the preferred response. Some candidates referred to straight lines without making it clear whether they were referring to horizontal or vertical lines.

(ii) Many candidates knew that as particle size decreased, rate of reaction increased. Furthermore, they were able to identify graph 3 as corresponding to the powdered calcium carbonate and graph 1 to correspond to the large lumps. It was fairly common to see the correct answer reversed. In some cases, the numbers were quoted in a random manner.

(iii) In common with answers to **(e)(i)**, many responses did not refer to the graphs. Others referred to straight lines without stating that they were horizontal or that the gradient = 0. 'It remains constant' or 'the graph is constant' were too vague to be credited.

(iv) Candidates performed poorly on this question. Despite being told that the calcium carbonate was in excess, many responses stated that the reaction stopped because the calcium carbonate had run out. Others referred to 'the reactants' without specifying that the hydrochloric acid had been used up.

<u>Question 3</u>

There were several excellent answers that gained full credit.

Despite being told that the two bottles containing the solids were unlabelled, many candidates started by stating 'add sodium carbonate to hydrochloric acid'.

It was insufficient to identify one of the two solids and thus identify the other by a process of elimination. Positive results for experiments carried out on both solids were required. Although a temperature rise was often reported for the reaction between sodium carbonate and hydrochloric acid, a drop in temperature when sodium hydrogencarbonate was used was reported less often.

Many unnecessary steps, such as testing the carbon dioxide evolved, collecting the carbon dioxide in a gas syringe and measuring its volume, measuring the loss of mass with time and plotting graphs were mentioned. Some described crystallisation of the products.

Calculation of the greater energy change per gram of solid involved:

- measuring the masses of both solids
- measuring the temperature change in both experiments
- dividing the temperature change by the mass of solid
- comparing the two answers.

Some candidates did not attempt to answer this question.

<u>Question 4</u>

This question was answered very well by the majority of candidates. There were many candidates who gained full credit for this question.

Hydrogen (instead of ammonia) was often mentioned as being given off in the test for nitrates

Some candidates did not attempt to answer this question.

<u>Question 5</u>

(a) This was answered correctly by almost all the candidates.

(b) When liquids are transferred from one container to another in a quantitative experiment, it is important to wash the container out two or three times with distilled water. The washings should then be transferred into the container in which the solution is being made up. This ensures that *all* the liquid is transferred and none is left behind

(c) The correct answer was known by a minority of candidates. Measuring cylinders, beakers and burettes were common answers.

(d) Candidates should be aware that during titrations the last liquid used to wash out the pipette (and also the burette) is the liquid that is being measured in the pipette (or burette). Washing out with water, the most common answer, would (slightly) dilute the solution that is being used, leading to inaccurate results.

(e) Candidates are informed that the aqueous potassium iodide and the dilute sulfuric acid are both in excess. For this reason, it is unnecessary to measure either of their volumes accurately. This was known by few candidates.

(f) Most candidates gained full credit for this question. The most common error was to record the initial burette reading in titration 1 as 0 instead of 0.0. A small number of candidates read the burettes upside down e.g. recorded 22.6 cm^3 as 23.4 cm^3 etc.

(g)-(m) Most candidates carried out all parts of the calculation extremely well and expressed their answers to three significant figures.

Better performing candidates who found their answer to **(m)** to be greater than 100%, which is an impossible answer, went back to **(f)** and checked all the steps of their calculations. In the majority of these cases, candidates inverted their expression so as to give an answer less than 100%.

Question 6

(a) Those who correctly identified oxygen as the product, occasionally stated that a burning splint relights as a test for oxygen. Several candidates gave hydrogen as the product.

(b) (i) The cathode should have been washed with distilled water and dried before weighing. Washing the cathode was often mentioned. Drying was often omitted. Some mentioned weighing the cathode here instead of in **(b)(ii)**.

(ii) Instead of stating an essential measurement, some candidates gave the name of the piece of apparatus used to make the measurement. Unnecessary measurements involving the electrolyte were occasionally seen. Time was occasionally mentioned.

(c) (i) Full credit was often awarded. It is advisable that the points on a graph are drawn to an appropriate size so that the lines are visible. The point at 1.12 was sometimes plotted at 1.02.

(ii) It was not uncommon for candidates to leave all the points uncircled. This applied even when the line did not go through the anomalous point. If candidates used circles to draw the points, the anomalous point was usually not distinguishable from the rest.

(d) (i) This was answered well by the majority of candidates.

(ii) This was answered less well, as the two lines did not always intersect

(e) Pink and brown were often seen. Candidates were asked for the colours of the electrolyte as opposed to the product at the cathode.