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 5070/22
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.

CHEMISTRY

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.