CHEMISTRY

Paper 5070/12
Multiple Choice

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

General comments

Candidates found **Questions 4**, **5**, **15**, **19**, **20**, **21**, **26**, **32** and **39** easy.

Statistical evidence indicated some candidates were guessing in **Question 34**.

Comments on specific questions

The choice of distractor in the following items revealed where some candidates have gaps in their knowledge, skills and/or misconceptions.

Question 10

Distracters **A** and **C** were common wrong answers. **A** is not an ionic equation and **C** has aqueous carbonate ions.

Question 12

Distracters **C** and **D** were common wrong answers. This highlights a poor understanding of 3(i) in the syllabus.

Question 13

Distracter **B** was chosen more than the key **(C)**. These candidates simply divided the two numbers provided and did not appreciate the difference in and use of the formula masses of the magnesium compounds.

Question 17

Distracters **C** and **D** were common wrong answers. These candidates did not use the provided M_r data to calculate the correct answer. It is also possible that candidates who chose **C** misread 'least' for 'most'.

Question 18

Distracter **C** was a common wrong answer. These candidates did not show knowledge that although the number of moles of acid was constant, the concentration of the acid used could be different.

Question 24

Distracter **D** was a common wrong answer. These candidates incorrectly linked the use of a high temperature in an exothermic reaction with an increase in the amount of product formed.

Question 25

Distracter **A** was chosen more than the key **(D)**. These candidates were not familiar with 7.4(b) in the syllabus.

Question 34

Distracters **B** and **C** were common wrong answers. These candidates did not or were unable to work out the number of moles needed for complete combustion.

Question 36

Distracter **A** was a common wrong answer. These candidates did not link the presence of enzymes in yeast with the process of fermentation.

Question 38

Candidates continue to find it difficult to correctly identify the structure of an ester from its name.

CHEMISTRY

Paper 5070/22
Theory

Key messages

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

General comments

Many candidates tackled this paper well and gained good marks in both ***Section A*** and ***Section B***. Most candidates gave answers of the appropriate length to questions involving free response. Some candidates did not follow the rubric and answered all four of the ***Section B*** questions. Most candidates responded to most parts of each question. The exceptions were **Questions 9(a)** (deduction of the structure of the monomer of poly(chloroethene)) and **Question 10(c)** (describing a chemical test to distinguish between a carboxylic acid and an alcohol). Some candidates wrote their answers first in pencil and then overwrote them in ink. This is a practice that should be discouraged, as it makes it difficult to read the candidates' writing. Other candidates put crosses against parts of their work but did not cross out these sections, which suggests that they were unsure which was the correct answer.

Many candidates need to write with greater precision and to include the key words, which will lead to a good answer. For example, in **Question 2(b)** many referred to strong bonding, but few referred to the structure of boron, other than to paraphrase the stem of the question. In **Question 4(d)**, many candidates wrote vague statements about pollution or did not state that *only* water is formed when hydrogen is used as a fuel. In **Question 6(a)**, some candidates just mentioned removing impurities, whereas in **Question 6(b)** others just mentioned factories or industries in response to the question about the origin of nitrates and phosphates in rivers. In **Question 8(c)(ii)**, essential words or phrases such as less *kinetic* energy and fewer *successful collisions* were omitted. In **Question 9(d)**, many candidates did not appreciate that the arrangement of particles relates to their order rather than their proximity. In **Question 9(e)**, many candidates referred to molecules and intermolecular forces when describing metallic bonding and did not use key terms such as delocalised electrons or sea of electrons or they used protons instead of ions. In **Question 10(a)**, some candidates used the term *oxygen molecules* instead of oxygen atoms when discussing why cyclobutanol is not a hydrocarbon. Candidates should be encouraged to write answers using key scientific words in their proper context.

Some candidates did not appear to read the stem of the question carefully enough. For example, in **Question 3(b)**, many candidates did not use the information in the stem of the question to deduce the correct structure of $TiCl_4$ or to deduce that (l) is the state symbol for $TiCl_4$. In **Question 3(c)**, many ignored the instruction to express their answers to two significant figures. In **Question 7(d)**, many candidates did not write the state symbols as instructed and/or gave the state symbol of Br_2 as (l), despite the statement in the stem of the question that aqueous bromine was used. In **Question 9(d)**, many candidates wrote about the movement of particles but did not write about the arrangement. Others did not heed the words 'liquid cools to become a solid' and wrote about melting rather than solidification. In order to improve their marks, candidates should underline or circle the key parts of the stem of the question and return to these to check that the question has been correctly answered.

A minority of candidates had a good knowledge of organic chemistry. Many others need to practice drawing the structure of monomers and polymers (**Questions 9(a) and 9(c)(ii)**). Others need to revise the properties of carboxylic acids as being typical of acids and different from alcohols (**Question 10(c)**). Some candidates need to refer back to the stem of the question, when dealing with the structures of compounds with which they are unfamiliar. For example, in **Question 10(b)**, some candidates suggested that the structure had C=C double bonds even though these were not present in the structure.

The writing of balanced equations was not always successful. Some candidates were able to work out the correct formulae for reactants and products. Others need more practice in memorising or working out simple formulae such as Br_2, I_2 or TiO_2. Many candidates need more practice in constructing ionic equations by identifying the spectator ions and cancelling these out (**Question 7(d)**). Others need more practice in balancing equations for the reactions at electrodes such as **Question 2(c)(iii)** where many candidates either did not balance the ions with the correct number of electrons or placed the electrons on the wrong side of the equation.

A few candidates had a good knowledge of structure and bonding. Others need further practice in distinguishing between molecular structures and giant structures and metallic structures (see comments on **Questions 2(b)**, **3(b)(i)** and **9(e)**). In such questions, candidates should also be advised to check that their answers do not contain conflicting statements e.g. 'it is a metallic structure with strong intermolecular forces'.

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. Other candidates should make sure that they set out each stage of their working clearly in calculations involving several successive steps. Statements in the form of 'moles of X =....' or 'from the equation, moles of Y =....' help to make clear the processes involved. Many candidates need practice in using the stoichiometry of the equation to work out the ratio of reacting moles. Candidates should also be advised not to round up their answers to a particular step in the middle of a calculation. Rounding to the correct number of significant figures should only be applied after the last step in a calculation.

Comments on specific questions

Section A

Question 1

This question was generally well answered.

(a) Many candidates gave the correct answer H_2S. The commonest incorrect answers were P^{3-} and Cl^-, possibly because they had 18 electrons.

(b) Many candidates identified the manganate(VII) ion. H^+, Fe^{2+} and Cl^- were the commonest incorrect answers.

(c) Some candidates ignored the reference to an ion and as a result gave CH_4 rather than NH_4^+. A few candidates suggested Cl^- or P^{3-}.

Question 2

Some candidates answered this question well. Many need more practice in answering questions about structure and bonding with the essential details (**(b)**) and in constructing ionic half-equations (**(c)(iii)**). Others need more practice in selecting the correct method for producing crystals of a soluble salt using a metal and an acid and writing the stepwise procedure. Candidates may find it helpful to answer this type of free response question using bullet points for each step.

(a) (i) Many candidates were able to estimate the atomic radius of nihonium. The most popular correct answers being in the range between 0.160 and 0.180 nm. Some candidates gave answers that were 100 times too high. Few gave answers less than 0.155 nm or more than 0.200 nm.

(ii) Most candidates appreciated the lack of a specific trend in the melting points. Some candidates used the context and referred to the radioactivity of nihonium preventing research to find the atomic radius. Other candidates recognised that the melting point both increased and decreased. A significant number of candidates wrote statements that were too vague such as 'it varies down the group'. Others did not refer to the data in the table and gave answers such as 'it's radioactive' or 'we haven't got the information'.

(b) Most candidates mentioned strong bonding, but fewer mentioned the presence of *many* bonds in boron. The most common misconception was to refer to the strong intermolecular forces or to repeat the stem about boron having a giant covalent structure.

(c) (i) Many candidates misinterpreted the meaning of the term composition. Some candidates gave the ratio of the ions present. The best answers gave aluminium oxide dissolved in molten cryolite. The name cryolite was not well known by many candidates so aluminium oxide was the only substance given as the answer. Some candidates just gave the formulae of the ions present in aluminium oxide. Others suggested bauxite, the ore, rather than the (purified) aluminium oxide.

(ii) The material (graphite or carbon) used to make the electrodes was well known. A minority of candidates suggested platinum or steel.

(iii) Most candidates gave the equation for the reduction of the aluminium ion. Fewer knew the oxidation of oxide ions. Some candidates referred to the 3 in $3Al$ and gave Al_3 as the product. Others tried to balance the aluminium ions with one or two electrons. A common misconception for the anode reaction was to show the oxidation of a hydroxide ion. Other common errors included $2e^-$ on the right, O_2^{2-} on the left and electrons added to the left-hand side. A significant number of candidates tried to make the number of electrons the same for each equation and sometimes got the multiples incorrect.

(d) Many candidates recognised that aluminium was oxidised and referred to the loss of electrons. The most common misconceptions were the choice of copper or copper ions or Al^{3+} on the right and Al on the left.

(e) Many candidates referred to the formation of an oxide layer; they often referred to its lack of reactivity rather than acting as a barrier. Some candidates gave answers suggesting that aluminium was a non-reactive metal being lower than hydrogen in the reactivity series.

(f) The best answers referred to excess aluminium, the use of hydrochloric acid, filtration and heating or evaporation then leaving to crystallise. Many candidates used aluminium oxide or hydroxide rather than the metal itself. Another misconception was to use a titration method rather than adding excess metal to an acid. Some candidates used a displacement type of reaction with a chloride rather than the reaction with hydrochloric acid. Candidates who chose metal and acid as their method of choice often used excess acid rather than excess metal. Candidates were often able to describe the crystallisation process with only a small proportion of candidates evaporating to dryness. Many candidates omitted filtration or only mentioned it in terms of filtering off the aluminium sulfate after crystallisation.

Question 3

Many candidates gave good answers to **(a)** and performed well in the calculation in **(c)**. Others need further revision about structure and bonding (**(b)(i)**), balancing equations and deducing state symbols.

(a) Most candidates were able to state one physical property of titanium. Only a small proportion gave chemical properties or confused properties of the element with those of the compounds e.g. coloured, catalytic activity and varying oxidation states. Other common errors included low melting point, low boiling point or low density.

(b) (i) Many candidates were not able to deduce the structure and bonding of titanium(IV) chloride and often referred to ionic bonding and/or a giant structure. Other candidates referred to simple molecular structures without mentioning covalent bonding or simple covalent bonding without mentioning molecules.

(ii) A considerable number of candidates got the formula for titanium(IV) oxide incorrect, typically giving TiO or TiO_4. In terms of the state symbols, $TiCl_4$ was often quoted as a solid or an aqueous solution. HC*l* was often written as HC*l*(l).

(c) Many candidates did not quote their answer to two significant figures. A common error was to get 227 by forgetting to round to two significant figures. Some candidates forget the 90% in the calculation or inverted this by multiplying mass or moles by 100/90. Moles and mass steps were generally well understood. The best answers were well organised with the steps being clear so that error carried forward could be rewarded. Other answers were more of a jumble of numbers with no real organisation. Some candidates muddled the formulae and as a result used the incorrect molar masses. Candidates should be advised to show their working as stepwise processes and clearly stating mass in g or moles as appropriate.

Question 4

This question was well answered by some candidates. In **(a)**, many candidates gained at least two of the three marks available and in **(c)** many were able to explain how the formula $C_{12}H_{26}$ indicates a hydrocarbon and were also able to balance the equation. Part **(d)** was the least well done, with many candidates not realising that the command word *explain* referred to the fact that they had to give a reason for their initial statement.

(a) Many candidates gave a suitable description of fractional distillation and the idea that the separation depended on the different boiling points of each fraction. Some candidates suggested that the column or the petrol was heated rather than the petroleum. Some suggested that the different fractions come off at different heights in the column. Others incorrectly suggested that petrol gases came off first, then petrol, then kerosene. A considerable number of candidates muddled the process of fractional distillation with the blast furnace or with cracking.

(b) The use of bitumen to make roads was well known. A small proportion of the candidates referred to roofing. Some candidates thought that bitumen was used as a fuel. Other common errors included ‘lubricant’ and ‘medicine’.

(c) (i) The best answers used the general formula and substituted n = 12 to show the correct molecular formula. Other answers just quoted the general formula. A common misconception was just to state that they both contained only carbon and hydrogen. A few candidates missed the H from the formula or gave the incorrect general formula as C_nH_{2n+1} or C_nH_{2n}.

(ii) A variety of correct equations were seen. The commonest involved the formation of $C_{12}H_{24}$. The most common error was to miss out the formation of hydrogen and give an equation that had an alkane and an alkene. A minority of the candidates did not add the numbers correctly and had two extra hydrogen atoms on the product side.

(d) Some candidates focused on economics or stated that hydrogen was cheaper or was obtained from the air. Others gave the flammability of hydrogen as a reason or described petrol as being more flammable. The best answers tended to focus on the disadvantages of petrol rather than the advantages of hydrogen. A significant proportion of the candidates appreciated that water was formed when hydrogen was combusted, but they often did not state it was the only product. Few candidates gave a reason related to their first statement e.g. ‘produces only water’ but without the explanation ‘so can be obtained from electrolysis of water, which is a renewable resource’. Therefore many candidates wrote two, three or four points but their explanation did not match the stated advantage e.g. renewable, makes no poisonous gases, gives more energy. Some candidates wrote very vague answers such as ‘less harmful’, ‘forms water’, or ‘no pollution’.

Question 5

This question was well answered by many candidates. The calculation in **(a)** was generally well done, although a significant minority of candidates omitted to calculate the percentage of oxygen. The calculation in **(b)** was less well done. Many candidates did not divide by three. Candidates should be advised to set out their calculations in a clear fashion giving statements such as 'mass of KOH =' and 'moles of KOH ='. This will help in the awarding of marks for error carried forward.

(a) A majority of the candidates were able to use the data to calculate the empirical formula and organised their answer in a table format that allowed error carried forward to be rewarded. Some candidates did not appreciate that they had to calculate the percentage of oxygen and as a result obtained an answer of CH. Others realised that oxygen should be present but just added it to the formula to give CHO. A small proportion of candidates inverted the expressions for the moles or used atomic number rather than relative atomic mass.

(b) Many candidates were able to calculate the moles of KOH present but sometimes did not appreciate how to calculate the moles of **W** present. A common error was to multiply the moles of KOH by three, rather than dividing by three. Some candidates rounded early in their calculations and as a result ended up with a molar mass that was larger than the expected 126. These answers were given full credit providing the working out was clear so the rounding used could be seen.

(c) The best answers not only calculated the correct molecular formula but also showed how they worked this out. A few candidates were confused by the label **W** and thought this was tungsten and used the letter in their formula.

Question 6

This question was well answered by many candidates. In **(a)**, the process of desalination was explained well by some candidates. Others wrote statements that were not specific enough. In **(b),** statements that were not specific enough were seen. The question about water purification in **(c)** was well answered by most candidates.

(a) Some candidates just repeated the stem of the question, rather than appreciating that desalination involves the removal of salt from sea water. A common example of this was 'purifying sea water making it fit to drink'. Some candidates wrote statements that were too vague, such as 'removal of impurities'. The best answers also explained how desalination is carried out e.g. 'removal of salt using reverse osmosis'. Many candidates just mentioned heating or distilling. Other candidates suggested 'removal of bacteria' or 'removal of solids'.

(b) (i) Most candidates appreciated that the two ions came from fertilisers. The commonest errors included vague statements such as 'factory waste', 'industries' and 'eutrophication'.

(ii) Some candidates correctly quoted the name eutrophication. Candidates that described what happened often gave imprecise answers e.g. 'grows algae' without mentioning increased growth of algae. A small proportion of candidates mentioned global warming, acid rain or ozone depletion. Many of those candidates who suggested harm to wildlife wrote answers that were not specific enough e.g. 'affects wildlife' or 'plants grow'.

(c) (i) This was generally answered well. Some candidates referred to use of filter paper rather than giving the large-scale methods such as screening or sedimentation; others suggested distillation.

(ii) Many candidates realised that carbon or charcoal is used to remove bad tastes from water. The commonest errors were to suggest either chlorine or fluorine.

(iii) A majority of the candidates recognised that chlorine is used to disinfect drinking water. The commonest error was to suggest carbon.

Section B

Question 7

Many candidates gave good answers to **(b)** (calculation) and **(c)** (test for iodide ions). Fewer gave good answers to **(a)** (description of how you know when the reaction is complete) and **(e)** (ionic conduction). Most candidates need more practice in constructing ionic equations (**(d)**).

(a) Some candidates used the state symbols in the equation provided to suggest that the solid would disappear. Many candidates referred to testing for ammonia instead. Others discussed the gases no longer being given off in a variety of ways e.g. 'stops effervescing',' litmus turns blue', 'litmus stops turning blue'. Others referred to the solid but gave incorrect answers such as 'the mass of the solid stays constant' or 'the solid turns brown'.

(b) Candidates were often able to demonstrate an understanding of how to do the calculation but did not account for the fact that the moles of gas was twice the amount of the moles of ammonium iodide. These candidates obtained $0.48\,dm^3$ rather than $0.96\,dm^3$. Only a small proportion of the candidates did not include the units for the volume. Other candidates made errors in the molar mass of ammonium iodide.

(c) The test for iodide ions was well known and many candidates included the presence of nitric acid as well as silver nitrate. A significant proportion of the candidates used lead nitrate rather than silver nitrate, which was acceptable. The commonest errors were to suggest barium chloride as the test reagent, to add hydrochloric acid instead of nitric acid or that the precipitate is white in colour.

(d) Few candidates constructed the ionic equation for the reaction of ammonium iodide with bromine. Many candidates gave the molecular equation instead. The formulae for the ions and the molecules were not well known and as a result, incorrect formulae were often used. Many candidates did not include state symbols. Other errors included bromide and iodide ions instead of bromine and iodine molecules; Br^+ and I^+ or a mix of ionic and incorrect non-ionic species. Common errors with the state symbols included $Br_2(l)$ (the stem of the question stated aqueous bromine) and $I_2(g)$.

(e) Some candidates realised that ammonium iodide is an ionic compound and answered the question in terms of the ions moving in aqueous solution but not moving in the solid state. A common misconception was to use the term 'free ions' rather than focus on whether the ions could move or not. A considerable proportion of the candidates wrote about electrons within the answer e.g. 'electrons cannot move in a solid but can in aqueous solution'. A few candidates did not read the stem of the question and wrote about ions moving in the molten state.

Question 8

Some parts of this question were well answered especially **(c)(i)**, **(d)**, **(e)** and **(f)**. In **(a)**, many candidates did not take note of the state symbols in the equation. In **(b)**, some candidates understood the change in composition of the mixture but many did not include the essential word 'gas' when trying to explain the change. In **(c)(ii)**, many candidates need more practice at writing answers to questions about rates of reaction with greater precision using the correct scientific vocabulary.

(a) Many candidates focused on having a backward and forward reaction rather than keeping reactants and products from escaping or gases from the air entering. Other candidates referred to keeping the conditions constant by having a closed system or defining dynamic equilibrium. Others wrote vague statements about outside conditions such as temperature and pressure not affecting the equilibrium.

(b) Many candidates did not understand the meaning of composition and referred to the position of equilibrium instead. As a result, only a small proportion of the candidates mentioned that the concentration of NO and O_2 would increase. In terms of an explanation, many candidates referred to the number of moles being greater on the reactant side; they did not mention the essential word 'gases' in this explanation.

(c) (i) Some candidates referred to the reaction being exothermic. Others either suggested that the reaction was endothermic or gave explanations more appropriate for a change in pressure, in terms of relative numbers of moles of reactants and products.

(ii) The best answers mentioned that the kinetic energy of the particles decreased and the number of successful collisions also decreased. Responses often contained omissions rather than incorrect chemistry e.g. not mentioning particles or molecules, missing off kinetic (energy) and only referring to collisions rather than successful collisions. Some candidates wrote about successive collisions instead of successful collisions.

(d) Many candidates drew a correct 'dot-and-cross' diagram for oxygen. Common errors included only a single shared pair and/or three lone pairs on each oxygen atom. Candidates should be advised not to draw the bonding pairs as an additional linking circle or to draw separate atoms with the bonding pair somewhere between them.

(e) Most candidates constructed the equation for the reaction of nitrogen dioxide with water correctly. The commonest error was to omit the 2 for balancing the nitrogen dioxide.

(f) Nearly all the candidates were able to describe strong and weak acids. Only a small proportion of the candidates referred to pH, reactivity or more H^+ ions (in strong acids) rather than ionisation or dissociation.

Question 9

Parts **(b)** and **(c)(i)** were generally well answered. Few candidates were able to draw the correct structure of the monomer in **(a)**. Many candidates need more practice in answering questions involving kinetic particle theory (**(d)**) and metallic bonding (**(e)**) using precise scientific terms.

(a) Many candidates did not draw the correct structure of the monomer, chloroethene. Common misconceptions included having the monomer with free extension bonds, drawing an alkene + chlorine. Only a minority of the candidates placed the *n* at the correct place in front of the monomer. A considerable number of candidates did not respond to this question.

(b) (i) Some candidates were able to balance the equation. A number of forms of correct equations were seen including either correct multiples or correct fractions. A common error was to attempt to balance the oxygen as $3O_2$ or $4O_2$.

(ii) Many candidates gave the correct answer by referring to hydrochloric acid or hydrogen chloride. Others referred to carbon dioxide being responsible for acid rain rather than focussing on the hydrogen chloride shown in the equation. A minority of the candidates suggested chlorine instead of hydrogen chloride. A few candidates did not take note of the elements present in the equation and suggested sulfur dioxide.

(c) (i) The uses of nylon were well known, with many candidates referring to cloths, fishing nets or threads.

(ii) Few candidates were able to draw the correct structure of the polypeptide. Some candidates appreciated the formation of the amide bond but drew block diagrams rather than the specific structure of the polymer. Extra hydrogen atoms and oxygen atoms were often included in the structures and a significant proportion of the candidates did not show the extension bonds at the end of the section of the polypeptide. Others omitted the H atom opposite the CH_3 group or drew three or more repeat units. A considerable number of candidates drew an ester linkage rather than a peptide/amide linkage.

(d) The best answers included statements about the particles moving from place to place in the liquid and slowing down until they were only vibrating in the solid, as well as statements about the particles going from a random arrangement in the liquid to becoming regularly arranged in the solid. Many candidates were not able to use the kinetic particle model to describe freezing. Many muddled the idea of arrangement with the idea of proximity (nearness) of the particles. Candidates did not focus on the motion and the arrangement and described the particles losing kinetic energy and moving closer together. Candidates rarely mentioned that the arrangement was random in a liquid and regular in a solid. Some candidates described melting rather than freezing. Others suggested the particles went from moving to a fixed position.

(e) The structure and bonding of a metal was often poorly described. Candidates often used ideas such as giant covalent, intermolecular forces or ionic bonding rather than the strong force of attraction between positive metal ions and delocalised electrons. Some candidates gave a good description of metallic bonding and then negated this by mentioning intermolecular forces. Many candidates did not use the correct terms when describing the electrons, using mobile or free electrons rather than a sea of delocalised electrons. Candidates should be encouraged to use precise terms when answering questions about structure and bonding.

Question 10

This was the best answered question from ***section B***. Parts **(c)** (energy profile diagram) and the calculations in **(d)** and **(e)** were generally well answered.

(a) Some candidates defined a hydrocarbon instead of explaining that cyclobutanol contains an oxygen atom as well as hydrogen and carbon. Some answers referred to the presence of the hydroxyl group while others incorrectly implied cyclobutanol as ionic by mentioning hydroxide ions. Others disadvantaged themselves by suggesting that oxygen molecules were present.

(b) The best answers described the lack of carbon-carbon double bonds. Candidates who mentioned carbon-carbon single bonds often did not mention that all the carbon-carbon bonds present in the molecule were single bonds. Some answers suggested that a saturated molecule only had carbon-carbon single bonds. Other common errors included reference to C=O bonds or C=C bonds being present (presumably through not referring back to the structure in the stem of the question).

(c) The commonest incorrect answer involved the test for unsaturation using aqueous bromine. This was not an appropriate answer since both molecules were saturated. Correct reagents included potassium dichromate, potassium manganate(VII), magnesium, calcium carbonate and universal indicator. Those who mentioned litmus often omitted the colour of the litmus paper to be used. Some candidates tried to answer the question by referring to bonding rather than describing a chemical test. A considerable number of candidates did not respond to this question.

(d) Many candidates completed the calculation correctly. The commonest error was to use 12 as the numerator in the calculation rather than 48. Another common error was to add up the atomic masses incorrectly, giving a molar mass of cyclobutanol of 71 instead of 72.

(e) (i) Some candidates gave the correct answer, ethanoic acid. Others either suggested methanoic acid or gave the non-specific ‘carboxylic acid’.

(ii) The commonest correct reagents given were oxygen, dichromate or manganate(VII). Incorrect oxidation numbers were ignored. Common incorrect answers included methanol, sulfuric acid or water.

(iii) The correct reagent, methanol, was rarely given. The commonest errors were to suggest sulfuric acid, phosphoric acid, permanganate or oxygen.

CHEMISTRY

Paper 5070/42
Alternative to Practical

Key messages

- If questions ask for observations or 'describe what is seen', answers should refer to some or all of the following:
  - colour changes (requiring initial and final colours)
  - effervescence
  - solids dissolving or disappearing
  - precipitates forming (with their colours)
  - heat changes
  - smells and colours of gases.

- If questions ask for observations it is unnecessary to refer to:
  - names of products
  - theoretical explanations
  - details of types of reactions

- It is unnecessary to describe a test for a gas unless the question specifically asks for one.

- Candidates should be familiar with the methods of preparation of salts that are listed on the syllabus. They should also be able to choose reactants that are suitable for the different methods of preparation of salts.

General comments

Poor handwriting was a notable problem from many candidates. Candidates should also be aware that if they wish to change an answer, they should cross out their original answer and replace it, rather than alter their original answer. Many alterations made the answer undecipherable.

Comments on specific questions

Question 1

(a) A large majority of candidates gave the correct names of the three pieces of apparatus. Volumetric flask was occasionally seen instead of conical flask. The spelling of the names was often incorrect. Biuret was commonly seen instead of burette.

(b) (i) The table was usually completed correctly. The initial reading in titration number 4 was occasionally shown as 48. This is because 23.6 + 24.4 = 48.

(ii) Candidates should be aware that the 'average' volume used in a titration calculation should be taken from the values that are closest together. In this case (assuming that the table was completed correctly) the closest values are 23.6 and 23.8. The most common error was to take the average of 23.3 and 23.6.

(iii) The reason for adding distilled water during a titration is to transfer any liquid that adheres to the sides of the conical flask into the body of the liquid in the flask. This means that all the magnesium hydroxide will react with the acid from the burette. The volume of water used does not affect the results of the titration because the volume of acid that is required to react with the magnesium hydroxide ***only*** depends on the number of moles of magnesium hydroxide in the flask. Water causes the concentration of magnesium hydroxide to decrease but does not affect the number of moles.

Common incorrect answers mentioned that water is neutral or that the same amount of water was used in each titration.

(c) All parts of the calculation were usually answered well by the majority of candidates. Answers were usually expressed to an appropriate number of significant figures. Candidates are advised to use three significant figures including trailing zeroes.

(i) Some candidates used 23.7 instead of 23.3. Answers were occasionally rounded too much as 0.014 or 0.01.

An occasionally seen incorrect answer was 0.003 from 5/23.3 × 0.014.

(ii) This was answered quite well.

(iii) The relative molecular mass of magnesium hydroxide was occasionally given as 41 (from MgOH = 24 + 16 + 1) even though $Mg(OH)_2$ is given in the stem of the question.

(iv) This was usually calculated correctly from the data provided. The most common incorrect response was 54.5(22) obtained by 2.34 × 23.3.

(v) Some candidates chose the wrong values to include in this calculation.

Question 2

There were many excellent descriptions of chromatography that gained full credit. Drawing the baseline in pencil was the information that was most frequently omitted. Other errors were using the food colouring as solvent or having the solvent level above the baseline. The baseline was occasionally labelled as the solvent front.

A small number of candidates used inappropriate methods such as distillation or fractional distillation.

An even smaller number did not attempt the question.

Question 3

The words ‘reduction’ and ‘discharging’ were frequently used inappropriately in answer to parts of this question.

- The term *reduction* in chemistry refers to gain of electrons or loss of oxygen as opposed to the dictionary definition i.e. get smaller.
- The term *discharge* in chemistry refers to the change occurring when ions lose their charge by loss or gain of electrons as opposed to the dictionary definition i.e. release.

(a) **(i)** ‘Describe what is seen’ means that observations are required. Large numbers of answers did not include observations.

The word ‘solid’ was often missing from the observation at the cathode. Observations at the anode should have been bubbles or fizzing or effervescence as opposed to gas evolved.There is no requirement to name the products. Ionic half–equations were seen often for no apparent reason.

(ii) A large number of candidates stated that a *burning* splint relighting is a test to identify oxygen.

(iii) Perhaps because copper is produced at the cathode, many candidates described the *solution* as turning pink, despite the fact that copper is a solid. The explanation of the colour fading because of the decreased concentration of copper *ions* was only mentioned by a small number of candidates.

(b) **(i)** The fact that there was no change to the colour was the expected answer. A significant number thought that the solution turned colourless.

(ii) There were many correct answers concerning the changes of mass of each electrode. Many candidates found it more difficult to explain that copper was removed from the anode and formed at the cathode. Some assumed that the anode was impure copper despite the information in the question.

(iii) Many correct answers including manufacture and purification of copper and electroplating were seen. Some candidates unnecessarily referred to uses of copper.

Question 4

(a) A wide variety of colours of iodine were seen. There was also frequent reference to precipitates and effervescence despite the state symbols that were given in the equation.

(b) **(i)** Only a small number of candidates realised that calcium carbonate would react with the acid and thus cause the reaction to stop.

(ii) A large number of candidates referred to the increase in surface area caused by powdering the calcium carbonate. Considerably fewer mentioned the effect on the rate of reaction.

(iii) The instruction ‘state what is observed’ was often ignored. Names of products and tests for gases were often given instead of observations. Precipitates were often referred to.

(c) **(i)** Most candidates plotted the points correctly.

Points should not be drawn with circles around them. This makes it difficult to see if the point is plotted accurately. It also means that it was very difficult to see if the anomalous point was identified correctly in **(c)(ii)**.

(ii) The anomalous point was identified quite often.

(iii) A smooth curve was drawn quite often.

(iv) (v)
Both were answered correctly by a very large number of candidates.

(vi) There were very few correct answers seen for this question. Only a small number of candidates realised that the shape of the graph provided information about changes of the rate of reaction between hydrogen peroxide and iodide ions in acid solution.

The term *slope* was not understood by large numbers of candidates.

Candidates were required to know that the slope (or gradient) decreased from 50 to 400 seconds, which indicated that the rate of the reaction between hydrogen peroxide and iodide ions in acid solution decreased. This was because the concentration of reactants decreased meaning that the collision frequency also decreased.

There was frequent inappropriate reference to sodium thiosulfate, iodine and calcium carbonate. None of these substances was a reactant in the reaction that was being investigated.

Question 5

Salts can only be prepared by titration in a reaction between an acid and an alkali. Thus, titration is an inappropriate method for both **(a)** and **(b)**. Titrations cannot be carried out using insoluble solids.

Copper(II) sulfate cannot be prepared using copper(II) sulfate. Silver chloride cannot be prepared using silver chloride.

(a) Copper was often suggested as a reactant, despite the fact that a compound was required and that there is no reaction between copper and dilute sulfuric acid. Using an excess of the copper compound was a frequent omission.

(b) A precipitation reaction is a reaction occurring between two aqueous solutions. Aqueous solutions were not always mentioned. The 'precipitate' was often produced by crystallisation of the filtrate.

Silver was frequently suggested as a reactant. Silver salts, other than silver nitrate, were also common.

Drying was often mentioned without suggesting how it would be done.

Question 6

(a) Candidates should be aware that if there are two marks for a question, two marking points should be given. It was common to see only one conclusion being offered instead of two.

An incorrect formula of the carbonate ion was commonly seen. Other ions in addition to carbonate were also seen.

(b) This was answered reasonably well. In some cases, the precipitate was said to be soluble.

(c) Candidates were required to make it clear that the white precipitate was insoluble *in excess*.

(d) This was answered reasonably well, although precipitates (other than slight ones) were occasionally seen.