CHEMISTRY

Paper 5070/11
Paper 1 Multiple Choice

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

General comments

Candidates found **Questions 2**, **3**, **4**, **13**, **33** and **35** easy.

Questions 10, **12**, **15**, **19**, **23**, **24** and **25** were found to be hard. Candidates found **Questions 10** and **23** particularly challenging and there was evidence of guessing on these questions.

Questions 23–26 are testing topics 8 and 9, transition elements, metals and alloys; candidates did not perform well on these questions.

Comments on specific questions.

The choice of distractor in the following items shows where candidates who performed less well overall, unless specified, have gaps in their knowledge, skills and/or understanding.

Question 1

Most candidates selected the key, but there was some evidence that better performing candidates chose option **A** rather than **C**. They did not consider the statement about the change in average distance between the particles.

Question 10

There was some evidence of guessing by candidates. The key was the option chosen by fewest candidates, which may indicate that many incorrectly think that mass is dependent on temperature and pressure.

Question 12

Option **D** was a popular incorrect choice. Candidates thought that activation energy, E_a, is the maximum energy and not the minimum energy required for particles to react.

Question 15

Option **B** was chosen by some candidates. These candidates correctly deduced that the rate of the forward reaction decreases. They incorrectly thought that decreasing the temperature of an exothermic reaction also reduces the amount of product in the equilibrium mixture.

Question 19

Candidates choosing option A did not know that HCl is a strong acid and so cannot be correct. Perhaps these candidates incorrectly thought the C in HCl was a carbon atom and so it is a (weak) organic acid.

Question 23

Options **C** and **D** were popular incorrect choices. Candidates have missed the incorrect chemistry: in **C** the hydrocarbons are 'saturated' rather than unsaturated and in **D**, the catalyst is used to oxidise 'sulfur' rather than sulfur dioxide.

Question 24

There was some evidence of guessing by candidates, including candidates who performed well overall. Options **B** and **D** were popular incorrect choices. Candidates have either misread 'innermost' for outermost' in statement 2 or did not know that Group 1 metals have low melting points.

Question 25

There was some evidence of guessing by candidates, including candidates who performed well overall. Option **C** was commonly chosen. Items on this part of the syllabus, 9.2.1, are usually answered correctly by most candidates.

Question 26

All the incorrect options, **A**, **B** and **D**, were chosen, indicating guessing by candidates. Items on this part of the syllabus, 9.2.2, are usually answered correctly by most candidates.

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Paper 5070/12
Paper 1 Multiple Choice

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

General comments

Candidates found **Question 15** easy.

Questions 8 and **15** were found to be challenging.

Comments on specific questions.

The choice of distractor in the following items shows where candidates who performed less well overall, unless specified, have gaps in their knowledge, skills and/or understanding.

Question 5

Option **C** was the most commonly chosen incorrect option, suggesting some candidates linked the number of electrons involved in bonds with the length of the formula. Option **B** was also selected by some candidates.

Question 8

Option **B** was chosen more than the key, including by some of the candidates who performed well overall. They did not make the link between covalent compounds and molecules and/or did not know that relative formula mass is used for ionic compounds. This is 3.2.2 in the syllabus.

Question 10

Option **C** was a popular incorrect choice. Choosing this option, candidates simply added the mass numbers of the two atoms and did not use the numbers of electrons in the outer shells to deduce the stoichiometry of the compound.

Question 16

There was some evidence of guessing. Option **A** was the most commonly chosen incorrect option. These candidates correctly deduced that this change gives a greater volume of gas, but not at the higher rate shown by the data. Option **C** was also chosen by some candidates.

Question 21

Some candidates selected option **A**. Candidates, including some candidates who performed well overall, did not link the acidic pH with the presence of aqueous ions and therefore it must be a conductor of electricity.

Question 26

Candidates incorrectly choosing option **C** either did not know that the number of outer shell electrons is the same in any given group or perhaps they thought that the more outer shell electrons there are, the more reactive the atoms are.

Question 34

There was some evidence of guessing by candidates. Options **A** and **C** were commonly chosen. The naming and drawing of esters, 11.2.3 of the syllabus, continues to be challenging for many candidates.

Question 35

Candidates often did not include the C–C bond in their total and so thought the key, option **A**, was incorrect and chose option **D**.

Question 36

Candidates who selected option **D** did not know that alkenes, whatever their source, can burn in air.

Question 38

There was some evidence of guessing by candidates. Options **B** and **C** were common incorrect choices. Most got either the correct concentration of sulfuric acid or the correct indicator.

Question 40

Candidates choosing option **C** correctly identified an ion giving a green precipitate and that carbonates can produce a gas, but not in alkaline conditions.

CHEMISTRY

Paper 5070/21
Paper 2 Theory

Key messages

- Candidates need to read questions carefully so that they answer what is being asked e.g. **Question 2(b)(ii)** where the question asked for an explanation in terms of electrons and also questions where reagents or products need to be named.
- It is important that candidates undertake practical work so that observations of chemical reactions are known.
- Candidates need more practice constructing balanced equations, particularly ionic equations.
- Many candidates did not understand equilibria and the drawing of structures of organic compounds.

General comments

Candidates were generally well prepared for this examination and had sufficient time to complete the paper, as only some of the more demanding questions were omitted. This is the first examination where all of the questions were compulsory.

Many gave detailed explanations for questions whilst others stated answers rather than explaining them.

Where a question asks for the name of a reagent to be given, a formula will only be acceptable if it is correct. Where the formula is required, a name is not acceptable.

Some candidates confused equilibrium with rate of reaction and success of collisions with collision frequency.

Generation of equations and the products of electrolysis were not well known.

Comments on specific questions

Question 1

(a) The thermal decomposition of limestone was well known. Other compounds used in the blast furnace were common, SiO_2 and Fe_2O_3.

(b) Candidates who performed well selected the amphoteric oxide. Fe_2O_3 was the more popular incorrect response.

(c) The majority of candidates recognised which oxide had a giant covalent structure. Fe_2O_3 and SO_2 were common incorrect responses.

(d) Oxidation number was quite well known. H_2O and Fe_2O_3 were popular responses.

(e) Candidates who performed well knew the test for water. All oxides were chosen with CO, Fe_2O_3, SO_2 and Al_2O_3 being the most common.

(f) Candidates who performed well chose a correct product of fermentation. All responses were seen.

Question 2

(a) Many candidates recalled one or two physical properties of Group 1. Common incorrect responses included high melting point, hard, high density, one electron in the outer shell and soluble in water or chemical properties including very reactive and react with water.

(b) (i) Candidates who performed well appreciated that the reducing agent is itself oxidised and so loses electrons. Many confused reducing agents with reduction and thought potassium gained electrons. A significant number did not explain their answer in terms of electrons.

(ii) Candidates found the oxidation number of an element quite challenging. The more common incorrect responses were +2 and +1.

(iii) Candidates found describing reaction observations very difficult. 'Produces a gas' is not an observation. Other common non-creditworthy responses included loses electrons, produces OH^- ions and reacts vigorously.

(c) The flame colour for sodium ions was not well known. Blue, green and red were common incorrect responses.

Question 3

(a) (i) The number of moles of zinc oxide was the most common correct step in the calculation. Many went further and calculated the number of moles of HC*l*. A significantly large number of candidates then calculated the mass of HC*l* and compared it to the mass of zinc oxide in the question.

(ii) Candidates found this challenging. Many discussed 'complete reaction' or 'maximising the yield'.

(iii) Many candidates appreciated that the mixture must be filtered. Distillation was the most common incorrect response.

(b) Candidates who performed well chose soluble barium and sulfate compounds. Common incorrect responses included: barium, sodium, sulfur, sulfate, sulfur oxide and incorrect formulae.

(c) (i) Nitric acid was generally well known but many candidates chose sodium for the acid.

(ii) Candidates who performed well selected the experimental technique; for others, neutralisation (the type of reaction) was the most common incorrect response. A significant number omitted the question.

Question 4

(a) Most candidates gave the correct numbers of particles in the ion. The most common error was to describe the phosphorus atom rather than the ion.

(b) Candidates found this very difficult. Common non-creditworthy responses included: in Group 2, is stable, has a stable octet, gains 3 electrons and has a valency of 3.

(c) Many candidates gave the correct formula. The most common error was using the PO_4^{3-} ion in the formula.

(d) Candidates found this very challenging. 'Giant' was very rarely seen. Many described covalent bonding or discussed the intermolecular forces in the ionic compound.

(e) The calculation was generally quite well done. Common errors included the mass of one atom of phosphorus leading to 10% or calculating the M_r of calcium phosphate incorrectly.

Question 5

(a) (i) Candidates found this challenging. The equivalence of the rates of the forward and backward reactions was quite well known by candidates who performed well. Many others thought that the concentration of the reactants and products were the same, rather than the concentrations not changing.

(ii) Candidates found this quite challenging. Many chose the correct direction of change but gave the explanation in terms of number of molecules or number of collisions. Many thought the reaction changed or went to the left.

(iii) Candidates found this very challenging. Of those that chose the correct direction of change, many discussed numbers or moles of molecules rather than gaseous moles or molecules. Many chose the opposite direction of change.

(b) Candidates found this very difficult and often gave their answers in terms of the change in the position of equilibrium. Those that did consider rate, often had the rate decreasing or discussed frequency of collisions rather than success.

(c) Candidates found this very difficult and often gave their answers in terms of the change in the position of equilibrium. Those that did consider rate, rarely considered the increase in particles per unit volume and often discussed success of collisions rather than frequency.

Question 6

(a) Candidates found this quite challenging; the whole range of marks were seen. The vertical axis was often labelled temperature, temperature change or energy change and the horizontal axis time, temperature or rate of reaction. The most common correct response was for a horizontal line labelled 'reactants'. A smaller number placed the products on a horizontal line to the right and at a lower energy level than the products. The enthalpy change of reaction was often given with a double headed arrow, no arrow or an arrow upwards. The activation energy was often from the products to the top of the energy 'hump'. Where the arrows were in the correct direction, they frequently did not reach as far as the reactants, the products or the energy 'hump'.

(b) The numerical answer was frequently correct but with a minus sign as the final subtraction was reversed. It is important for the + sign to be included in an enthalpy calculation since the sign is the indication of endothermicity. Some omitted doubling the 298.

Question 7

(a) The majority of candidates gave the correct formula. A small number gave $C_nH_{2n}OH$.

(b) (i) Isomerism was well known. A small number of isotopes seen.

(ii) The structure of the isomer was quite well known. Some drew propan-1-ol or an ether.

(c) Saturated was generally well understood. A significant number of candidates omitted the concept of 'only'.

(d) Hydrocarbon was well understood. Of those that defined hydrocarbon, a small number omitted the concept of only hydrogen and carbon.

(e) (i) Candidates found drawing the displayed formula difficult. Of those that drew propanoic acid, there were many missing hydrogens with 2 and 3 valent carbon atoms and no bond between the O and H. Many drew propanol, butanoic acid, propane, had a double bond to the OH or included MnO_4 or $KMnO_4$ in their structure. A significant number of omitted the question.

(ii) Candidates found this very challenging. Incorrect drawings included a double bonded linking oxygen, a 2 valent hydrogen, an alcohol, a diol, a triol, 2 and 4 valent carbon atoms, 3 valent oxygen atoms or an extra CH_2. A significant number omitted the question.

(f) (i) Candidates found this difficult. Incorrect responses included CH_4, CH_3 bonded to an OH as one entity or had the correct orientation of atoms and bonds but with no non-bonded electrons.

(ii) Candidates found this challenging. Many discussed electrons but described them as free or delocalised rather than mobile. A significant number discussed moving ions.

(g) Solvent was generally well known. Some described a solute, had a solution dissolving a solute or a substance dissolving in a solute.

Question 8

(a) Candidates who performed well identified the products. Many candidates gave ions, incorrect formulae e.g. O, I and H or wholly or partly reversed the anode and the cathode.

(b) Candidates found describing the observations of the electrolysis very difficult and a significant number omitted the question. Non-creditworthy responses included copper goes from the cathode to the anode and the cathode gets bigger.

(c) The ionic equation was challenging for many candidates. Many equations started with Cl_2, Cl or $2Cl$, or had $2Cl^- + 2e^-$.

Question 9

(a) Candidates found this challenging. Some calculated the volume of NO and then used this to calculate the number of molecules. Some divided either the volume of NO or the number of moles of NO by the Avogadro constant. Some manipulated the numbers with no chemical understanding of the question.

(b) Many candidates generated the equation. Incorrect responses included: $N + O \rightarrow NO$, $N + O_2 \rightarrow NO_2$, $N_2 + O_2 \rightarrow NO$.

(c) The adverse effects of NO_x were well known.

(d) Candidates found this very challenging. Common non-creditworthy responses included: reacts with oxygen, breaks down, reacts with catalysts, forms NO_2 and releases harmful substances.

(e) (i) Terminology proved to be an issue here. Many discussed NO_2 being heavier with no refence to molecules; it having a larger A_r or molar mass, or just NO_2 is bigger.

(ii) Many candidates discussed higher energy with no reference to kinetic energy or the molecules moving faster, or discussed NO moving slower with no reference to any form of particle or only discussed more collisions.

Question 10

(a) More successful candidates derived the structure of the monomer. Many gave the repeat unit or put a single C–C bond in the monomer.

(b) (i) Carbon monoxide was well known. A small number of candidates gave carbon dioxide.

(ii) Many candidates stated an environmental challenge without explaining it. Many stated land or water pollution, which was insufficient. Ozone depletion and forming toxic carbon monoxide were popular incorrect responses.

(c) Candidates found this challenging. Many named poly(ethene) or other addition polymers. The linkage was often drawn with no linking bonds or a portion of the polymer was drawn. A significant number omitted the question.

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Paper 5070/22
Paper 2 Theory

Key messages

- Candidates must be able to distinguish between the key ideas related to chemical equilibria and rate of reaction. Answers involving chemical equilibria should not use collision theory and answers involving rate of reaction should not include arguments about the position of equilibrium.
- Candidates should ensure that they give the name of a substance if asked for the name and a formula if asked for a formula in the question. Even if the question asked to identify a substance, candidates should be advised it is better to give the name since they are less likely to get the formula correct.
- Candidates need to read the questions carefully to ensure that they include all the requirements for a question and do not include irrelevant information.
- Candidates often had misconceptions about the greenhouse effect and confused this with ozone depletion.

General comments

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

In quantitative questions, some candidates did not show sufficient working out so it was not always possible to award error carried forward marks.

Comments on specific questions

Question 1

Almost all the candidates followed the rubric and gave the formula of the oxide rather than the name. Candidates need to be careful that the formula is written clearly where there is a possibility of confusing symbols. In particular, the difference between CaO and CuO is not always obvious.

(a) Many candidates chose H_2O but CO was also quite popular.

(b) The most common incorrect answers were CO and CaO rather than SiO_2. Other candidates chose SO_2.

(c) Many candidates appreciated CuO reacts with dilute hydrochloric acid to give a blue solution. Other common incorrect answers were CaO and ZnO.

(d) Many candidates appreciated that ZnO is an amphoteric oxide.

(e) Many candidates chose Fe_2O_3.

(f) Candidates did not always recognise that SO_2 would decolourise acidified potassium manganate(VII). A common error was to give SiO_2 rather than SO_2.

Question 2

This question was about Group VII.

(a) The appearance of iodine at room temperature and pressure was not well known. Candidates were more likely to give the correct state rather than the colour of iodine. The most common misconceptions were that iodine was a brown liquid or that it was a purple colour.

(b) (i) Although many candidates appreciated that chlorine gains electrons, some candidates gave answers that referred to oxidation number and this type of answer was not given credit. A small proportion of the candidates confused oxidising agent with oxidation and referred to chlorine losing electrons rather than gaining electrons.

(ii) Some candidates gave the correct oxidation number of iodine as 0 but others gave –1.

(iii) Many candidates did not give an observation but gave an answer that explained why a displacement reaction happens. Even those candidates that gave observations often gave incorrect observations such as red, black or purple solutions. Only a small proportion of candidates mentioned the formation of a brown solution. Some candidates thought that iodine was formed as a gas.

(c) (i) The definition of diffusion was well known, and the best answers referred to the random motion of particles to give a net movement from high to low concentration. Some candidates did not mention what was moving (either particles or a substance) and just mentioned movement from high concentration to low concentration.

(ii) Some candidates forgot that the smallest particles of fluorine were molecules rather than atoms. As a result, candidates often gave answers that referred to atoms of fluorine having less mass than atoms of chlorine. To be awarded credit, there had to be a clear comparison between the mass of fluorine molecules and chlorine molecules. A reference to fluorine having a smaller relative molecular mass was allowed but fluorine having a smaller atomic mass was not allowed. A common misconception was that the rate of diffusion was related to the reactivity of the halogen.

(iii) Many candidates gave answers that were better suited to a question about rate of reaction. However, if these answers clearly indicated that the fluorine particles were moving faster or had more kinetic energy they were given credit. References to more successful collisions were ignored. A small proportion of the candidates referred to just energy rather than kinetic energy and/or did not link a particle to the ideas of more kinetic energy or moving faster.

Question 3

This question was about the preparation of salts.

(a) (i) Candidates used several different methods to show zinc carbonate was in excess in the reaction between zinc carbonate and dilute nitric acid. Most approaches started by calculating the amount in moles of zinc carbonate and of dilute nitric acid. Some candidates then calculated the actual moles of zinc carbonate that would react with the dilute nitric acid. Alternatively, candidates used the amount of zinc carbonate to calculate the amount of nitric acid that would be needed to react with this amount. Other candidates calculated the mass of zinc carbonate that would react with the amount of nitric acid available. Many answers were very clear, with their working out shown and as a result it was possible to follow approaches that were unusual. A common misconception was to calculate the mass of nitric acid needed and compare this mass with the mass of zinc carbonate given.

(ii) Candidates had to relate their answers to the preparation of zinc nitrate, so the best answers appreciated that the mixture was filtered to remove the excess zinc carbonate. Imprecise answers such as removing impurities were not given credit.

(iii) A considerable proportion of the candidates focused on how to obtain the aqueous zinc nitrate rather than how aqueous zinc nitrate was changed into zinc nitrate crystals. A common misconception was to heat the solution to dryness rather than heating to obtain a saturated solution and then cooling this mixture. Answers often mentioned filtering but were not specific to the actual stage of making crystals to which this referred. The idea of washing the crystals before attempting to dry them was rarely mentioned. Many candidates dried the crystals using filter paper.

(b) Candidates rarely gave the names of a soluble lead compound and typically used insoluble salts such as lead sulfate, lead chloride and lead bromide. Other candidates used lead hydroxide or lead metal and dilute hydrochloric acid. Candidates generally chose suitable soluble chlorides.

(c) Candidates were not always careful to distinguish between ammonium and ammonia and so answers such ammonia hydroxide or ammonium were sometimes given. Ammonium carbonate was not given credit since it is not a base. A small but significant proportion of the candidates gave other ammonium compounds such as ammonium sulfate or ammonium chloride.

Question 4

This question was about compounds that contain magnesium and nitrogen.

(a) Many candidates were able to deduce the number of sub-atomic particles in the nitride ion. Candidates were more likely to get the number of neutrons and number of protons correct than the number of electrons.

(b) Candidates found this question very challenging and often just referred to the loss of two electrons and did not explain that the resulting ion had a stable electronic configuration. References to a stable outer octet of electrons or eight electrons in the outer shell were also acceptable. Even candidates that mentioned eight electrons often neglected to refer to the outer or valency shell.

(c) Many candidates could use the formula of the ions to deduce the formula of magnesium nitride as Mg_3N_2. A common misconception was to leave the charges of the ions in the formula.

(d) Candidates often gave at least one correct physical property. Since the decomposition of nitrates is beyond the syllabus, high boiling or melting point was allowed. The idea that magnesium nitrate is soluble in water or insoluble in organic solvents were also common answers. Answers that described electrical conductivity had to ensure that the physical state was included within their answer e.g. conducts electricity as a molten liquid.

Question 5

This question was about chemical equilibria and rate of reaction.

(a) (i) Candidates often appreciated the importance of stopping substances entering or leaving the system. No credit was given for keeping the conditions constant. Some candidates mentioned it was to keep the rate of the forward equal to the rate of the backward reaction without explaining any further.

(ii) Various ways of stating that the position of equilibrium moved to the left, for example the reaction moves backwards, moves towards the reactants or moves to the side of carbon and steam, were accepted. The best answers explained that the position of equilibrium moves to release thermal energy to minimise the effect of lowering the temperature. Alternative answers included moved in direction of the exothermic reaction, the backward reaction was exothermic, or the reaction was endothermic.

(iii) Various ways of stating that the position of equilibrium moved to the right, for example the reaction moves forwards, moves towards the products, moves to the side of carbon monoxide or moves to the side of hydrogen, were accepted. The correct answers included the reactants have fewer moles of gas or the products have more moles of gas. A common misconception was that the position of equilibrium did not move because the number of moles were the same on the reactant and product side. Other candidates gave the correct movement of the position of equilibrium but did not include the significance of mentioning gases in their answer.

(b) Many candidates ignored the words in bold in the question and gave an answer based on chemical equilibria rather than rate of reaction. Candidates often repeated answers they had given in **(a)**. Candidates did not appreciate that the answers required were not related to whether the reaction was the backward or the forward reaction. The candidates only had to give answers based on collision theory. The best answers appreciated that the rate decreases because the particles have less kinetic energy or are moving slower so that the collisions are less successful. Only a very small proportion of the candidates referred to fewer particles having energy less than the activation energy.

(c) As in **(b)**, many candidates ignored the words in bold in the question and gave answers based on chemical equilibria rather than rate of reaction. The best answers referred to more particles per cm^3 and then to more frequent collisions and as a result stated that the rate increases.

Question 6

This question was about the energy changes that take place during chemical reactions.

(a) There was lots of confusion about the labels for the axes. A common misconception was to use rate as the *y*-axis and time as the *x*-axis. Enthalpy change or energy change were not accepted for the label to the *y*-axis; the label had to be just 'energy' or 'enthalpy'. In terms of the *x*-axis, the label had to be 'progress of reaction' or an equivalent. Some candidates left the axes blank.

Most candidates appreciated that the reactants had to be on the left-hand side and written over a straight horizontal line to represent the energy level. The word reactants or the formula of at least one reactant was accepted for the reactant mark. Only a very small proportion of the candidates put the reactants on the right-hand side.

Since the reaction was endothermic, the products had to be both on the right-hand side and above the reactants. The word product or at least one correct formula was accepted for the product mark. A small proportion of the candidates did position the product for an exothermic reaction.

Some candidates did not show the direction of the enthalpy change. This was best done by an arrowhead pointing upwards. Candidates also needed to be careful to show clearly where the line starts and where it finishes.

Some candidates started the activation energy from the level of the product rather than the reactant. The best answers showed the activation energy as an upward arrow and candidates should ensure that the arrow starts at the level of the reactant, be drawn vertical and go to the 'energy hump'.

Some candidates did not label the energy changes or placed them in ambiguous positions, so it was not possible to distinguish between the enthalpy change and the activation energy.

(b) Typically, candidates did not show clear working out but just a collection of numbers with a final answer on the answer line. The best answers calculated the energy change associated with bond breaking and on the line below the energy associated with bond forming. These answers then clearly showed that bond forming was exothermic with a minus sign. Candidates who did not show the working out were unlikely to be awarded credit for error carried forward since it was not possible to discern the working out. A small proportion of the candidates did not use the stoichiometry of the equation and so ended up in the last stage of the calculation as 629 – 366 rather than 629 –732.

Question 7

This was a question about alkenes.

(a) The general formula C_nH_{2n} was well known and only a very small proportion of candidates gave C_nH_{2n+2}. Some candidates put a plus sign in the formula, $C_n{+}H_{2n}$.

(b) (i) The meaning of the term structural isomers was well known, although a common misconception was to refer to the same chemical formula rather than the same molecular formula.

(ii) Candidates found this question quite difficult and often drew structures with either five bonds around a carbon atom or only three bonds around a carbon atom.

(c) (i) The meaning of the term unsaturated was well known.

(ii) The meaning of the term hydrocarbon was quite well known but a significant proportion of the candidates forgot to mention the word only in their answer i.e. contains only hydrogen and carbon.

(d) (i) Either an unambiguous structure for butan-1-ol or butan-2-ol was accepted. Most correct answers were partial displayed formula with the hydroxyl group shown as –OH. Candidates must be careful when writing this type of structure to ensure that the correct bonding is shown; carbon bonded to oxygen bonded to hydrogen.

(ii) Candidates found this question more challenging that **(d)(i)** and often included an –OH bond. Other candidates retained the double bond and had bromine atoms attached to the other end of the carbon chain. Other misconceptions included having 1, 1-dibromobutane and 1, 4-dibromobutane.

(e) (i) Candidates very rarely attempted an ionic dot-and-cross diagram. The most common misconceptions were drawing ethane, having a single bond between the two carbon atoms and/or showing lone pairs on the carbon atoms.

(ii) Some candidates mentioned weak bonds but did not specify the type of weak bonds. The best answers referred to weak intermolecular forces. Other candidates did not mention any attractive forces between molecules but just mentioned ethene had a simple structure. This was not sufficient to be awarded credit. Two common misconceptions were that the intermolecular force was between atoms or between bonds.

Question 8

This question was about electrolysis and many candidates found the question challenging.

(a) Candidates were most likely to name the products of the electrolysis of dilute sulfuric acid with some giving both water and oxygen for the anode product. With lead(II) bromide, a common misconception was to give the cathode product as lead(II) rather than lead. The most common misconception was to give the names or formulae of ions rather than the products. Only a very small proportion of the candidates gave all the correct products but assigned them to the incorrect electrodes.

(b) Candidates were often able to give two reasons why graphite is a suitable material from which to make electrodes. The most common answers were it was inert and had good electrical conductivity. The other common reason was graphite has a high melting point. No credit was awarded for either references to cost or a high boiling point.

(c) Candidates found the half-equation very challenging despite the information given in the stem of the question. Some candidates included aluminium in the equation and a common error was to have the electrons on the incorrect side of the equation. Some candidates did not use the formula for oxygen molecules. Candidates also found it difficult to balance the number of oxygen atoms on each side of the equation. Some candidates gave the formula for the oxide ion as O^-.

Question 9

This question was about carbon dioxide.

(a) Candidates found this question challenging and often missed out at least one of the steps of the calculation. The best answers gave working out that involved calculating the moles of carbon dioxide using the molar gas volume, using the data about 0.0400% carbon dioxide by volume and finally, multiplying the amount in moles by the Avogadro constant. Candidates often only did one or two of these steps in their calculations. Although many candidates appreciated that somewhere in the calculation they had to multiply by the Avogadro constant, some did not show sufficient working out to be credited with error carried forward marks.

(b) If candidates knew the products of the reaction, they were often able to balance the equation. Some equations given by candidates lacked oxygen as a reactant.

(c) (i) A significant proportion of the candidates stated that ozone depletion was an adverse effect of global warming. Other candidates just referred to temperatures increasing, which was not sufficient. The most common correct answers mentioned sea level rising, drought, flooding and melting of glaciers and polar ice caps.

(ii) Candidates found this question very challenging and often gave answers that referred to the energy from the Sun being absorbed by the carbon dioxide. This energy was often UV. Candidates also mentioned ozone depletion. Only a small proportion of the candidates appreciated that the carbon dioxide absorbed thermal energy radiated from the Earth and it then re-emitted the radiation back into the atmosphere.

(d) Candidates did not always recall the correct starting materials for photosynthesis and sometimes gave equations for respiration. Candidates often gave a symbol equation rather than a word equation. The symbol equation was given full credit, but candidates should appreciate the difference between a word equation and a symbol equation. Other candidates described the overall reaction of photosynthesis in words without putting it into a word equation format; this was not given credit. Candidates should be advised that energy should not be included in an equation as though it is a substance.

Question 10

This question was about polymers and polymerisation.

(a) (i) A significant proportion could not draw the structure of an amino acid. Many answers still had a peptide bond present or drew two monomers: a diamine and a dicarboxylic acid. The candidates who drew the correct structure either drew a structure with a box connected to a –COOH and a $–NH_2$ group or the general structure of an amino acid showing the R group. Some candidates drew the carboxylic acid with the wrong connectivity with respect the –OH group in the carboxylic acid.

(ii) The most popular correct answer given was nylon. Common misconceptions included carbohydrates, DNA and fats.

(b) (i) Many candidates recognised the ester linkage in the structure of PET.

(ii) The most common answer referred to the formation of a byproduct such as water during condensation polymerisation but no byproduct during addition polymerisation. Candidates who tried to give a difference related to the structure of the monomers often struggled to give a clear answer.

(c) The three environmental challenges in the syllabus were given credit, along with the idea that plastics are non-biodegradable or take a long time to decay or decompose. Candidates that mentioned only land pollution, air pollution and water pollution were not given credit since there had to be some more detail. Air pollution had to be linked with incinerating plastics and forming a known atmospheric pollutant or a toxic gas; land pollution had to be linked to the need for land-fill sites and water pollution to accumulation of plastic in seas or oceans, blocking of sewage pipes or killing marine organisms.

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Paper 5070/31
Practical Test 31

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

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Paper 5070/32
Paper 3 Practical Test

Key messages

- It is important that candidates read questions thoroughly. In particular, the detail given in the planning question explains to candidates exactly what is required in their plan and these instructions need to be followed fully.
- Care needs to be taken when doing qualitative experiments such as titrations to ensure that results are as accurate as possible.

General comments

In **Question 1**, some candidates had little idea about how to process data from a titration and so performed poorly in these parts.

Question 2 was well answered overall, particularly in regard to the candidates' ability to do the experiments and record correct observations.

In **Question 3**, many candidates were able to tackle the planning question effectively and perform well.

Comments on specific questions

Question 1

(a)(b) This was generally well answered. Candidates were able to take burette readings, but some did not express the readings to an appropriate number of decimal places. There were some candidates who reversed the initial and final readings and a few who incorrectly calculated the volume. There was considerable variation in terms of the accuracy of the results, with many candidates having results significantly different to the Supervisor. Candidates also need to appreciate the importance of repeat values being close to one another.

(c) Most candidates were familiar with the colour change, although some reversed the colours.

(d) There were a wide variety of unacceptable answers given, often related to keeping the conical flask stable. The key purpose of the white tile is to help candidates discern the colour change at the end-point so as to obtain a more accurate volume in the titration.

(e) From the answers given, it appears that some candidates did not understand the meaning of the term 'mean volume'. Candidates need to be familiar with the term 'mean' as well as 'average'.

(f) Some candidates who knew how to process the data did not express their answer to an appropriate number of significant figures. It is expected that candidates not only understand the mathematical principle of significant figures but are also able to decide on an appropriate number of significant figures from the context of an experiment and the choice of apparatus used.

(g) The idea that a solution of ammonia is made by dissolving a given volume of a gas was not understood by some candidates and so they did not understand how to use the data provided for the volume of one mole.

(h) This question asks candidates to use the answers to **(e)** and **(g)**. Few candidates were able to use the ratio of the titration volumes to scale the volume of gas from **(g)**.

(i) This question tested a candidate's understanding of the techniques used in a titration and how they relate to the accuracy of the result. The idea that washing the burette with water left some water behind in the burette, which would dilute the acid, was not known by many. Those who did understand this, did not always realise that this will result in a larger titration volume. Vague and unexplained comments about accuracy were insufficient.

(j) Few candidates were able to suggest why universal indicator is not suitable for a titration. Some candidates seemed to think that universal indicator only exists in paper form and so made comments about having to dip it in the solution repeatedly rather than talking about the variety of colours shown by universal indicator and the consequent difficulty in determining an end-point.

Question 2

(a) Most candidates recorded a green precipitate, although some thought that it dissolved in excess sodium hydroxide.

(b) Most candidates recorded a white precipitate.

(c) Some candidates reversed the answers, suggesting that sulfate was the cation.

(d) Some candidates did not describe the observation of effervescence or bubbling. Saying that 'a gas was produced' was insufficient as an observation, as they are told in the question that a gas is produced. Few candidates described the change in colour of the solution.

Some candidates did not correctly identify the gas produced. The most common error was to think that hydrogen was given off.

(e) Most candidates recorded a brown precipitate, although some thought that it dissolved in excess sodium hydroxide. Some candidates thought that a green precipitate was produced as in **(a)**.

(f) Most candidates who had obtained correct observations in **(e)** were able to identify the cation from their results.

(g) Some candidates did not describe the observation of effervescence or bubbling. Saying that 'a gas was produced' was insufficient as an observation, as they are told in the question that a gas is produced. Few candidates described the dissolving of metal **X** to form a colourless solution. solution.

Some candidates did not correctly identify the gas produced. The most common error was to think that oxygen was given off.

(h) This question required candidates to realise that **X** was a metal because metals produce hydrogen when reacted with an acid. There were a wide range of suggestions as to the identity of **X** but the most common was to suggest that it was 'a carbonate', even when they had not recorded any experimental evidence to this effect.

Question 3

Many candidates were able to tackle the planning question effectively and perform well. However, some candidates omitted the question completely.

Candidates are expected to include comments about all of the bullet points mentioned in the question. Omitting any one of these prevented the candidate from obtaining full credit on the question. For example, failing to name pieces of apparatus or failing to control variables.

Some candidates did not note the point in the question which says that they have baking soda but 'no other chemicals'. This resulted in plans which involved either the making of bread or reacting baking soda with acid. Although these methods could show which of the two different samples had been stored for longer and some credit was given for the plans, failure to follow the instructions given prevented candidates from gaining full credit.

Some candidates chose to draw a diagram, although it was not essential. Credit was given for answers shown in either text or a diagram.

A few candidates suggested methods which were totally inappropriate such as crystallisation, distillation, and chromatography.

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Paper 5070/41
Paper 4 Alternative to Practical

Key messages

- In **Question 3**, it was important that candidates made full use of the 'Notes for use in qualitative analysis' pages provided.
- In **Questions 2(a)(i)** and **2d**, candidates should be aware of the appropriate number of significant figures to use.
- For **Question 4**, candidates should have recognised that the question involved the planning of an investigation to be carried out in a Chemistry laboratory, using only standard laboratory equipment and the chemicals referred to.

General comments

Overall, candidates answered questions well. Most candidates understood the need for the chromatography set up shown in **Question 1**. Successful candidates showed clear workings for the calculations in **Question 2** and gave answers to an appropriate number of significant figures. The majority of candidates used the 'Notes for use in qualitative analysis' pages to correctly answer **Question 3**. **Question 4** was very well answered by most candidates, clearly fulfilling the bullet points in the question.

Comments on specific questions

Question 1

(a) Most candidates were able to identify the beaker.

(b) While the better performing candidates were able to recognise that the purpose of the lid was to reduce loss of solvent by evaporation, others incorrectly tried to justify the lid in relation to chemicals from outside entering the beaker.

(c) This question was separated into two parts. The second part of the question was answered successfully; the majority of candidates were able to explain that pencil is used for the start line because pencil will not dissolve into the solvent (unlike pen). The first half of the question proved more difficult for the candidates. Some of the candidates used the same reasoning for both sections of the question, stating that the start line is above the level of the solvent so that it does not dissolve. As the start line is in pencil, it would not dissolve anyway, so this answer is incorrect. The best responses recognised that the start line is above the solvent so that the food colouring does not dissolve off the paper into the solvent, explaining that if the start line was below the solvent level then the dyes would not travel up the paper and be separated.

(d) The majority of candidates were able to calculate the Rf value correctly. As this was a 2 mark question, candidates should be encouraged to show their working as, if their final answer is incorrect, 1 mark would still be available for the correct working.

Question 2

(a)(i)(ii) Both parts of this question involved reading values correctly from an image of a burette. Most candidates were successful on this question. There were some candidates that gave the initial value on Titration 1 as '0' rather than '0.0'. Candidates should be reminded that burette readings should be given to one decimal place.

(b) Most candidates calculated the two means correctly.

(c) The majority of candidates correctly identified that titrations are repeated to ensure consistent results. There were some candidates that said the repetition is carried out so that a mean can be calculated. While a mean is calculated, a mean could also be calculated from very varied results, so this is not the reason for the repeats. The reason is to obtain results that are consistent and reproducible.

(d) Most candidates correctly calculated the correct number of moles of **B** used; fewer candidates correctly used this value to then calculates the concentration of ethanoic acid. The question also asked for the answer to be to an 'appropriate number of significant figures'. Candidates should recognise that three significant figures is the appropriate number for a calculation such as this.

(e) The majority of candidates were able to calculate the mass of ethanoic acid correctly.

(f) Most candidates were aware that they should use a ratio of the two means in the calculation of this question, but they often got the ratio the wrong way around. Candidates should double check what the question is asking for and think what value they would expect to get, before doing the calculation. In this case, the question was asking for the mass of ethanoic acid in **A**. As the mean volume of **A** used was larger than that of **B** (to neutralise the same amount of sodium hydroxide), it must follow that **A** has less ethanoic acid in it than **B**. If candidates then carry out the calculation, being aware that they are expecting a value less than the answer for **(e)**, it is easier for them to see if they have the ratio the wrong way around.

(g) Most candidates recognised that if the flask was rinsed with some sodium hydroxide, that some may remain in the flask. Only a minority of candidates then took this further and stated that, if more sodium hydroxide was in the flask, then more ethanoic acid would be needed to neutralise the sodium hydroxide in the following titration. Some candidates approached the answer from a different direction and explained that distilled water is used to remove any remaining chemicals in the flask and that the distilled water would not affect the number of moles of ethanoic acid needed. Full credit was available for either approach.

(h) Approximately half of the candidates recognised that the brown colour of the vinegar would mask the colour change of the indicator, making the colour change harder to see.

Question 3

Throughout this question, candidates should have made full use of the 'Notes for use in qualitative analysis' pages at the back of the question paper.

(a) (i) This question states that aqueous sodium hydroxide was added to a solution and the solution remained colourless. From this information alone, candidates should have been able to look at the 'Tests for aqueous cations' table at the back of the paper and conclude that an ammonium cation must have been present. The table also tells them that, if an ammonium cation is present, ammonia is produced on warming. Therefore, the first action the candidate in the question must take would be warming the solution. The candidates should then have looked at the 'Tests for gases' table to provide the test for ammonium gas. A significant number of candidates wrongly looked at the test for nitrate ions and referred to the addition of aluminium foil.

(ii) This question refers to the observation in test 3. Test 3 states 'Add dilute hydrochloric acid then aqueous silver nitrate to **W**'. Candidates should have been able to look at the 'Tests for anions' table and recognise that aqueous silver nitrate is used in the tests for halides. A number of candidates answered this question by stating that both sulfates and chlorides would give a white precipitate. This is incorrect; the test for sulfates involves the addition of barium nitrate, not silver nitrate (as the candidates could see from the table of anion tests). For those candidates that did indicate that chloride ions would give the white precipitate, only a minority then recognised that the anion could not be identified because these chloride ions could have been from the hydrochloric acid that had been added.

(iii) This question was answered much more successfully. The majority of candidates recognised that sodium ions should give a yellow flame.

(iv) Most candidates successfully identified the cation and anion in **W**.

(b) (i) Most candidates correctly understood the term 'observation' and stated that effervescence would confirm the presence of a gas.

(ii) The majority of candidates described a suitable way of introducing the solution into the flame and correctly described the flame colour that would be produced. The point that was sometimes omitted was to state that a blue, or roaring, Bunsen burner flame should be used.

(iii) This question was well answered, with most candidates gaining full credit. Candidates could answer either by describing the test for copper(II) ions using aqueous sodium hydroxide or using aqueous ammonia.

Question 4

This longer question required candidates to carefully read the description given and respond appropriately. It was not expected that candidates were familiar with this specific experiment but tested their ability to apply their knowledge of laboratory skills and equipment. A number of candidates were able to answer this completely and obtain full credit. The best answers clearly referred to all the bullet points in the question, recognised the need to use the same masses of the baking powder samples and to carry out the investigations at the same temperature. Whilst most candidates did give a plan using only common laboratory equipment, water and baking powder (as requested), some candidates gave their answers related to baking cakes. These candidates gave plans which used additional ingredients and an oven. Candidates should be reminded that, although the context for the question is given (that baking powder is used in making cakes), the investigation should be able to be carried out in a laboratory using the equipment and processes that candidates are familiar with from their Chemistry course.

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Paper 5070/42
Paper 4 Alternative to Practical

Key messages

- Candidates need to develop the ability to apply general practical and theoretical knowledge to experiments set in contexts which they have not previously encountered.
- Candidates need to be aware of and use the data sheet provided which gives information about qualitative analysis.
- It is important that candidates read questions thoroughly. In particular, the detail given in the planning question explains to candidates exactly what is required in their plan and these instructions need to be followed fully.

General comments

In **Question 1**, candidates seemed unfamiliar with this experiment, but this should not have prevented them from correctly answering each part. Candidates were expected to work out the answers by application of their knowledge of the fact that oxygen and water are both needed for iron to rust. The question also tested candidates' ability to understand how investigations need to control variables in order to draw a valid conclusion.

In **Question 2**, most candidates seemed to be familiar with titration experiments.

Overall, **Question 3** was well answered. Candidates now have access to the data sheet for qualitative analysis, but answers suggested that some candidates were not making effective use of this. Centres should encourage candidates to be familiar with the content of these pages of the examination paper.

In **Question 4**, many candidates were able to tackle the planning question effectively and it was generally quite high scoring.

Comments on specific questions

Question 1

(a) The majority of candidates correctly answered this introductory question.

(b) Many candidates thought that the stopper was to prevent things leaving the test-tube rather than preventing water entering. Other candidates thought it was to prevent oxygen/air from entering. Whilst this is true that air/oxygen cannot enter, it is not relevant as air is already in the test-tube. The air in the test-tube is labelled as 'dry air' and this should have given candidates the idea that water needs to be prevented from entering.

(c) Few candidates seemed to be aware that water contains dissolved air and that this can be removed by boiling. A number of candidates suggested that the heat was to increase a rate of reaction.

(d) Although candidates often recognised that the oil formed a barrier layer, few suggested that it prevented the entry of oxygen/air.

(e) Despite generally poor answers to **(b) – (d)**, many candidates were able to identify Experiment **A** and explain that both oxygen/air and water are needed for rusting.

Question 2

(a)(b) This question was generally well answered. The most common mistake was for candidates not to record all values to one decimal place. Many candidates wrote 0.0 rather than 0 for titration 1, however, they did not carry this concept forward and many wrote 15 rather than write 15.0 when calculating the volume for Titration 2. This suggests that they had possibly learnt to write 0.0 in titrations but did not understand the principal of recording all values to one decimal place as an indicator of the precision of the experiment.

Some candidates gave values to two decimal places; this was acceptable as long as the second figure was a 0 or 5 as it is possible to read a burette to +/– half of a division of the scale.

(c) Many candidates were familiar with the idea that a white tile helps to make the colour change easier to see. Some candidates thought it was just to stabilise the conical flask.

(d) Although quite a lot of candidates found this straightforward, a significant minority did not understand the term 'mean volume' and calculated other values instead. Candidates need to be familiar with the term 'mean' as well as 'average'.

(e) A number of candidates knew how to do this calculation; a significant number were unable to express the answer to an appropriate number of significant figures. In the case of most titrations, the appropriate number of significant figures is 3. Candidates are expected to be able to look at a method and determine the number of significant figures to use based on the precision of the apparatus used.

(f) Candidates who were familiar with the expression:
volume of gas = volume of one mole x number of moles of gas
were able to complete this part correctly. A significant number of candidates made no response.

(g) Few candidates were able to use the ratio of the titration volumes to scale the volume of gas from **(f)**.

(h) Many candidates demonstrated an understanding of the reasons for washing equipment in a titration.

(i) Few candidates were able to suggest why universal indicator is not suitable for a titration. Some candidates seemed to think that universal indicator only exists in paper form and so made comments about having to dip it in the solution repeatedly rather than talking about the variety of colours shown by universal indicator and the consequent difficulty in determining an end-point.

Question 3

(a) (i) This question tested the candidates' ability to identify and use the data provided to select and describe the appropriate test to identify Fe^{2+} ions.

(ii) This question required candidates to be aware that potassium manganate(VII) is an oxidising agent and so will oxidise Fe^{2+} to Fe^{3+}. Most candidates knew that the starting colour of the potassium manganate(VII) is purple but almost all candidates stated that it changed to colourless rather than recognising that the Fe^{3+} formed in the reaction would cause the final colour to be yellow.

(iii) Many candidates did not realise that the mixture from **(a)(ii)** now contained Fe^{3+} and so this question required them to use the data sheet to describe the observations made when aqueous ammonia is added to aqueous Fe^{3+}. Most candidates described the effect of aqueous ammonia on Fe^{2+} instead.

(b) (i) This question required candidates to note that **X** was a metal and to know that metals produce hydrogen when reacted with an acid. Those who identified hydrogen were mostly able to describe the test and observation correctly. There was a wide variety of different gases suggested.

(ii) The key word in this question was 'observation'. Candidates' answers often repeated an observation that had already been given. For example, stating that the temperature increased when they had been told it became warmer was not one **other** observation. Many candidates did not recognise that the observation which shows that a gas is produced is effervescence or bubbling or fizzing.

(iii) A significant number of candidates thought that the silver nitrate test is for chloride ions rather than chloride, bromide or iodide. Some candidates suggested carbonate or nitrate when the test is fully described in the data provided. A number of candidates incorrectly stated that the halide ions were in solid **X** rather than in the solution.

(iv) This was generally well answered although, as in **(iii)**, some candidates thought that solid **X** contained sulfate ions.

(v) Many candidates found this part difficult and were unable to link the tests in **(iii)** and **(iv)** to the identification of the acid.

(vi) A wide range of incorrect answers were seen here and candidates appeared not to have read the repeated the fact that **X** is a metal. There were a variety of compounds suggested and carbonate was also a common incorrect answer.

Question 4

Candidates were expected to include comments about all of the bullet points mentioned in the question. Omitting any one of these prevented the candidate from obtaining full credit on the question. For example, failing to name pieces of apparatus or failing to control variables.

Some candidates did not note the point in the question which says that they have baking soda but 'no other chemicals'. This resulted in plans which involved either the making of bread or reacting baking soda with acid. Although these methods could show which of the two different samples had been stored for longer and some credit was given for the plans, failure to follow the instructions given prevented candidates from gaining full credit.

Some candidates chose to draw a diagram, although it was not essential. Credit was given for answers shown in either text or a diagram.

A few candidates suggested methods which were totally inappropriate such as crystallisation, distillation, and chromatography.