CHEMISTRY

Paper 5070/11
Multiple Choice

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

Comments on specific questions

The paper consisted of 40 questions which involved choosing the correct answer from four alternatives.

Candidates found the following five questions the most accessible: **2**, **9**, **15**, **22** and **24**. The most challenging questions are analysed in further detail below.

Question 1

Responses to this question revealed that candidates across the ability range have the misconception that oxygen is itself flammable.

Question 25

This question was discarded.

Question 33

Many candidates did not appreciate that SO_2 is a pollutant from the combustion of petrol/diesel.

The choice of distractor in the follow items revealed where weaker candidates had gaps in their knowledge and/or misconceptions:

Question 7

Methane was a popular wrong choice for a substance with a giant molecular structure.

Question 13

Candidates often did not appreciate that production of H_2 and O_2 in electrolysis is from water and so leads to increased concentration of the acid.

Question 16

Candidates were often unable to manipulate the energy profile diagram to the reverse reaction.

Question 27

A significant proportion of candidates thought that coke and slag were removed from the bottom of the furnace, rather than iron and slag.

Question 34

Weaker candidates struggled to identify the correct structure/name of the ester from the reagents.

Question 35

Responses to this question highlight a misconception that atoms/groups on the carbon atoms either side of double bond are able to swap positions in the polymerisation process.

CHEMISTRY

Paper 5070/12
Multiple Choice

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

General comments

The paper consisted of 40 questions which involved choosing the correct answer from four alternatives.

Candidates found the following questions the most accessible: **6**, **13**, **20**, **21**, **23**, **24**, **26**, **29**, **30**, **33**, **37** and **38**. The most challenging questions are analysed in further detail below.

Comments on specific questions

The choice of distractor in the follow items revealed where weaker candidates had gaps in their knowledge and/or misconceptions:

Question 8

Many candidates were not aware that SO_2 is used as a bleach.

Question 9

Many candidates appeared not to use the data to work concentrations of reagents. If they did, then they did not relate that to which reagent was in excess.

Question 10

A degree of guessing by weaker candidates was evident, i.e. they struggled with the stoichiometry/volumes of the gases in the equation.

Question 14

Candidates were often unable to manipulate the energy profile diagram to the reverse reaction.

Question 15

May candidates did not appreciate that change in state from a gas to a liquid is an exothermic process.

Question 16

Distractor **C** was a common wrong choice, indicating that weaker candidates did not appreciate that as the same volume of gas is produced, the concentration is the same.

Question 27

A significant proportion of candidates thought that brass does not conduct electricity.

Question 39

A significant proportion of candidates thought that proteins contain no more than three elements.

CHEMISTRY

Paper 5070/21
Theory

Key Messages

Candidates need to show all relevant working out when completing calculations so that marks can be awarded for intermediate steps even if the final answer is incorrect.

Candidates must distinguish between rate of reaction and position of equilibrium when discussing and explaining the conditions used in industrial processes.

Questions involving the kinetic theory of matter were found to be challenging. The candidates should ensure that the answer refers to the correct specified particle for the question e.g. ions for ionic compounds and molecules for simple molecular compounds.

General Comments

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

Most candidates answered only three questions from section B but a small proportion of candidates answered all four.

Comments on Specific Questions

Section A

Question A1

This question was about oxides.

(a) Many candidates recognised silicon dioxide as the oxide having a giant covalent structure.

(b) Candidates often recognised that zinc oxide would react with acids and alkalis.

(c) Candidates often recognised that sulfur trioxide reacts with water to make a strong acid. The most common incorrect answer was sulfur dioxide.

(d) Candidates often recognised that sodium oxide contained a cation with a charge of +1. The most common incorrect answers were calcium oxide and zinc oxide.

Question A2

This question focused on atoms and atomic structure.

(a) Many candidates could recall the relative charges and relative masses of subatomic particles.

(b) (i) Candidates often deduced that the nucleon number was 85.

(ii) Many candidates compared the numbers of protons and electrons and appreciated that there were more electrons. Some candidates referred to atoms losing electrons rather than using the information in the table.

(iii) Some candidates recognised that **C** and **E** were isotopes. A common misconception was to include **D** in the answer, however **D** was an ion rather than an atom. Candidates were often able to explain what was meant by the term isotopes.

Question A3

This question was about the preparation of salts by titration and precipitation.

(a) Many candidates could write the ionic equation for neutralisation.

(b) (i) Many candidates could give the name of a correct sodium compound. Sodium carbonate was the most popular choice. A small proportion of candidates chose sodium oxide but this was not given credit since it reacts with water and so cannot be made into an aqueous solution.

(ii) The titration method was well known by some candidates and descriptions often included the three required marking points. Some candidates did describe repeating the experiment without the indicator but did not include sufficient detail and neglected to mention that the same volumes had to be used. A significant proportion of the candidates did not attempt this question.

(iii) Some candidates described a method that involved evaporating to dryness rather than heating the solution until the solution becomes saturated. No candidate mentioned washing with an organic solvent to dry the crystals; most candidates preferred to describe drying using filter paper which was also credited. A significant proportion of the candidates did not attempt this question.

(c) (i) Often candidates did not show all their working and as a result it was often difficult to award any marks for error carried forward. The correct answer was 2.563 g but correct answers rounded to one or two decimal places were accepted. The most common error was to fail to convert the volume in cm^3 to dm^3. Some candidates did not attempt this question.

(ii) Candidates had to use their answer to **(i)** to get a percentage yield of 74.91. Candidates could quote an answer between 73.8 and 75 since this accounted for any rounding the candidate did in **(i)**. Often candidates did this calculation correctly, however some inverted the expression for percentage yield since their answer to **(i)** gave a percentage yield above 100%

Question A4

This question was about calcium chloride.

(a) Many candidates could give the correct electronic configurations. They were both 2.8.8. A significant proportion of the candidates used orbital notation and gave the answer $1s^2 2s^2 2p^6 3s^2 3p^6$, while correct, this type of answer is well beyond the expectation of the syllabus,

(b) Candidates found the electrode reaction at the negative electrode much easier than the one at the positive electrode. A significant proportion of the candidates had the electrons on the wrong side of the equation for formation of chlorine, other candidates gave the incorrect formula for chloride ions.

(c) Some candidates gave the correct products as hydrogen and chlorine however a significant proportion of the candidates gave calcium or oxygen as products.

(d) A significant proportion of the candidates referred to molecules or intermolecular forces even if the rest of the answer mentioned ions. Candidates rarely mentioned the idea of many bonds having to be broken.

Question A5

This question was about alcohols.

(a) Many candidates could describe the manufacture of ethanol. Typical answers included the name of the catalyst, the correct temperature and the correct pressure. The syllabus has no requirement for the correct pressure so references to pressure were ignored.

(b) (i) Many candidates referred to the use of ethanol as a solvent.

(ii) Candidates were often able to write an equation that was not balanced but found writing the balanced equation much more difficult.

(c) Candidates often chose oxygen as their answer. This was accepted in the mark scheme along with potassium dichromate(VI) and potassium manganate(VII). Centres should advise candidates to take care when writing the name of chemicals because the use of maganate was not given credit.

(d) Candidates were often able to draw an isomer of butanol, but a common misconception was to draw butan-1-ol a second time. Other candidates drew the –O–H group as –OH and this was not given credit as the question asked for all of the bonds to be shown.

(e) Candidates often tried to draw butene but sometimes included pentavalent carbon atoms or neglected to include the carbon-carbon double bond. Some candidates drew but-2-ene and this was given credit even though it could not have been a product of the reaction, because this knowledge was beyond the syllabus requirements.

(f) (i) Many candidates recognised addition polymerisation.

(ii) Candidates often appreciated that non-biodegradable means the polymer would not decay or decompose naturally.

Question A6

This question was about photosynthesis.

(a) Candidates often got the relative position of the energy levels for the reactant and the product correct but struggled to use the correct labels for the axes. Common misconceptions included labelling the *y*-axis as energy change and the *x*-axis as rate of reaction or temperature. Most diagrams included an activation energy but this was not required to gain full marks.

(b) (i) Candidates often referred to an enzyme as a catalyst but this was not sufficient and the answer had to be a biological catalyst. Other candidates just referred to something that speeds up a chemical reaction. A small proportion of the candidates appreciated that an enzyme is a protein.

(ii) Candidates often recognised that an enzyme speeds up a reaction although some candidates mentioned that they slow reactions as well.

(c) Candidates were often confused by the context of the question and focused on photosynthesis rather than why a reaction goes faster at a higher temperature. Those that did answer about rate of reaction often gave answers that referred to particles having more kinetic energy and went on to mention there were more successful collisions.

Section B

Question B7

This question focused on the chemistry of copper.

(a) Some candidates did not focus on the observations that would be made but gave answers such as copper nitrate is made. The most popular correct answer referred to the formation of a blue solution.

(b) (i) The name copper nitrate or the more systematic copper trioxonitrate(V) was often given by candidates. There was no need to give the oxidation state of the copper but if it was included it had to be correct. A small proportion of the candidates recognised that a brown gas would be formed.

(ii) A common misconception was that copper had gained oxygen. The best answers involved copper losing electrons or that the oxidation state of copper increased from 0 to +2.

(c) A significant proportion of the candidates could calculate that 4.8 dm^3 of gas was made. Some candidates neglected to include the units and as a result they were not awarded full marks. A common misconception was to use the molar volume at room temperature and pressure as 22.4 dm^3 rather than 24 dm^3. Good answers showed all the steps in the calculation and so allowed the award of marks for working even if the final answer was not correct.

(d) Many candidates could balance this equation. A significant proportion of the candidates used fractions to balance the equation – this was credited.

(e) (i) Candidates often referred to a blue precipitate that in excess gave a dark blue solution.

(ii) Candidates often referred to the formation of a blue precipitate.

Question B8

This question was about iodine(I) chloride.

(a) Candidates found this question very challenging and they did not appreciate that both sodium chloride and sodium iodide would be formed. Often the equation gave a halogen as one of the products.

(b) Candidates found this question much less demanding than part **(b)** and they were often able to draw the correct displayed formula.

(c) Although many candidates understood the reaction was an example of substitution they could not always give an equation and often hydrogen was one of the products with both halogens being incorporated into the organic product.

(d) Some candidates could draw the 'dot-and-cross' diagram for iodine(I) chloride, but other candidates left the question blank.

(e) (i) Many candidates could define a dynamic equilibrium although they often did not mention that the concentrations of all species do not change. A common misconception was that the concentrations of all species were equal.

(ii) The most able candidates appreciated that the right-hand side had fewer moles so as the pressure increased, the position of equilibrium moved to the right. These candidates used this shift in the equilibrium to predict that the colour would become more yellow or less brown. Other candidates focused on rate of reaction rather than chemical equilibria. A significant proportion of the candidates did not attempt this question.

Question B9

This question was about the noble gases.

(a) The most common uses given by candidates was in filament light bulbs or as an inert atmosphere in welding.

(b) Candidates often gave vague or unspecific answers to this question, for example, it is an element with one atom. The best answers referred to a molecule with only one atom.

(c) The reason why the noble gases are very unreactive was well known and most candidates referred to a full outer shell of electrons.

(d) (i) The best answers in this calculation worked out the amount of each element in the sample, then the mole ratio and finally wrote down the empirical formula of XeO_2F_4. Some candidates used the atomic (proton) number rather than the relative atomic mass to calculate the amount in moles; these candidates did not score. A small proportion of the candidates used O_2 and F_2 to calculate a relative formula mass rather than using the relative atomic mass to calculate the amount in moles.

(ii) Many candidates understood they needed the relative formula mass of the compound.

(e) Candidates found this question challenging and often only mentioned the difference in boiling points of the noble gases. Most candidates did not appreciate that the mixture had to be liquefied before it could be fractionally distilled. A significant proportion of the candidates did not attempt this question.

(f) Some candidates understood that it was the difference in relative atomic mass that allowed diffusion to be used as a separation technique.

Question B10

This question was about the homologous series of carboxylic acids.

(a) (i) Many candidates could deduce the general formula for the carboxylic acid homologous series. A variety of correct answers were given including $C_nH_{2n}O_2$, $C_nH_{2n+1}COOH$ and $C_{n-1}H_{2n-1}COOH$.

(ii) Candidates often gave two properties of a homologous series. The most common given were they had the same functional group, similar chemical properties and physical properties that vary with an observable trend. Some candidates gave examples of similar reactions e.g. they are all made using the same general method.

(b) (i) Candidates often gave good definitions for a weak acid either referring to partial ionisation or dissociation.

(ii) Candidates found this question quite demanding and even if they appreciated that carbon dioxide and water were formed, they were not able to write the correct formula for magnesium propanoate.

(c) Some candidates could name and draw the displayed formula for the ester ethyl butanoate, however, a small proportion drew butyl ethanoate instead. Other candidates did not know the atoms in the ester linkage and as a result drew incorrect structures. A small proportion of the candidates did not attempt this question.

(d) Only the very best candidates could get all three marks and most candidates only mentioned the particles moving faster or moving away from each other. The idea that both in the liquid and in the gas the particles were arranged randomly was very rarely mentioned.

CHEMISTRY

Paper 5070/22
Theory

Key Messages

Many candidates need more practice in organising their answers in a logical manner and in writing chemical names correctly.
The construction of ionic equations needs more practice.
The origin and sources of atmospheric pollutants were not well explained.

General comments

Some 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. Others gave answers which were far too vague or not related to what was expected from the stem of the question e.g. in **Question B8(f)(i)** many did not refer to an experimental method and in **Question B10(d)** many candidates wrote vague answers relating to kinetic particle theory and wrote about the proximity of the particles, ignoring their arrangement.

Some candidates wrote chemical names correctly. Others gave names of esters which were open to misinterpretation e.g. ethnate. Similarly many wrote potassium (per)manganate as potassium magnate, so it was uncertain whether it was a compound of magnesium or manganese.

The writing of balanced equations was not always successful, a major obstacle for some candidates being to work out how to construct ionic equations. **Questions A3(b)** and **A4(b)** caused particular problems in terms of identifying the ions and balancing the equations.

Many candidates answered the equilibrium question **B8(d)** in terms of kinetic particle theory and rate of reaction. Many candidates need more practice in interpreting whether the question relates to equilibrium or rate of reaction.

Many candidates were able to describe the tests for the copper(II) ion. Others need further revision on practical aspects of chemistry such as **Question A3(a)(ii)** on salt preparation and purification. In question **B8(f)(i)** hardly any candidate realised that for the experimental method to work, the concentrations of the strong and weak acid should be the same. In addition, few candidates described a suitable experimental method and concentrated on the results instead.

Many 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. Candidates should be encouraged to follow this method. Others gave no explanation of what they were doing or the relevant units: g or mol or mol dm^{-3}.

Many candidates need further practice in explaining the origin and sources of atmospheric pollutants (**Question B9(a), (b) and (c)**) and in explaining how the carbon cycle keeps the amount of carbon dioxide in the atmosphere relatively constant (**Question A6(c)**).

Comments on specific questions

Section A

Question A1

This was generally well answered. Candidates generally scored well in most parts. The exception was part **(d)** where hydrogen chloride was often incorrectly chosen.

(a) Most candidates recognised that copper(II) chloride is a coloured solid. The commonest incorrect answer was to select zinc chloride, which is a d-block element but not a transition metal.

(b) This was almost invariably correct. A few candidates chose zinc chloride.

(c) Many candidates correctly selected hydrogen chloride. The commonest incorrect answers were calcium chloride or magnesium chloride.

(d) Few candidates selected ammonium chloride. The commonest misconception was to suggest hydrogen chloride. Candidates should make sure that they distinguish between the covalent compound hydrogen chloride and the ionic solution, hydrochloric acid. Calcium chloride and magnesium chloride were other common incorrect answers.

(e) Most candidates chose carbon tetrachloride. Others gained a mark by selecting hydrogen chloride, which also has a molecular structure..

Question A2

This was the best answered question on the Paper. Most candidates scored well in part **(a)** and **(b)(ii)**. Fewer gave a suitable definition of the term *isotope* in part **(b)(i)**.

(a) Many candidates scored well, most giving the correct number of protons, neutrons and electrons. A significant number of candidates did not score the mark for ^{37}Cl, the commonest errors being ^{35}Cl or $^{37}Cl^{-}$. Many did not score the mark for $^{85}Rb^{+}$ because either the charge or mass number was omitted. Others wrote the incorrect symbol, Ar and Br being typical errors of this type.

(b) (i) Some candidates gave a good definition of the term *isotope*. The commonest error was to omit the essential word ‘atom’. Others omitted the word ‘number’. A few candidates mentioned different numbers of protons.

(ii) Many candidates selected a suitable pair of isotopes. The commonest errors were either to give the names or symbols of two different elements or to give the symbols for an ion and an atom e.g. $^{79}Br^{-}$ and ^{81}Br.

Question A3

In part **(a)** some candidates were able to identify a suitable acid and base and gave a good description of the preparation of magnesium chloride crystals. Others did not gain many marks because they chose an incorrect method of preparation or heated the crystals to dryness. In part **(b)** those candidates who wrote an ionic equation usually gained both marks. Others did not appear to understand what is meant by the term *ionic equation*. The calculations in part **(c)** were generally correct.

(a) (i) Many candidates disadvantaged themselves by not writing the name of hydrochloric acid. Many just wrote HCl, which refers to hydrogen chloride. Others suggested magnesium carbonate which was not accepted.

(ii) Some candidates wrote detailed answers, giving the correct sequence of processes for producing a pure dry sample of magnesium chloride. Others chose incorrect reagents such as sodium chloride or magnesium nitrate even when they had not mentioned these in part **(a)(i)**. Incorrect methods included titrations and precipitation. A significant number of candidates either did not mention filtration or took the residue for crystallisation. Others suggested that the crystals should be evaporated to dryness. Although many candidates mentioned washing and drying, fewer gave further information to explain exactly how to carry out these processes.

(b) Those candidates who wrote an ionic equation usually gained both marks. Many wrote molecular equations, but these were rarely correct, with K_2Cl or KCl_2 often given as an incorrect co-product. Molecular equations were rarely balanced correctly and so could not get the mark for the state symbols. Other common errors included Ba^+ instead of Ba^{2+} and SO_4^- instead of SO_4^{2-}.

(c) (i) Most candidates did the calculation correctly showing relevant working. A minority of the candidates halved the number of moles unnecessarily. A few candidates misread their calculators, having the correct working but giving a final answer as 2.62 g instead of 2.26 g.

(ii) Many candidates calculated the correct percentage yield. A number of candidates inverted the fraction, especially if they had obtained an incorrect answer to part **(c)(i)**.

Question A4

This question was fairly well answered. The exceptions were part **(b)**, where many candidates wrote an incorrect equation for the reaction at the positive electrode and part **(c)**, where some wrote about electrons and others did not mention movement of the ions.

(a) A majority of the candidates deduced the electronic configurations correctly. The commonest errors were either to give the electric configuration of the atoms rather than the ions or to add an extra electron shell e.g. 2, 8, 8.

(b) The equation for the discharge of sodium at the negative electrode was better known than the equation for the discharge of oxygen at the positive electrode. Only a few candidates muddled the electrode products. Common errors at the cathode included reversal of the equation, the absence of a charge on the sodium ion and sodium written as Na_2. Common errors at the anode included balancing with 2 electrons, giving an equation with OH^- ions as the reactant and writing incorrect oxide ions e.g. O_2^- or O^-.

(c) Some candidates gave correct answers involving moving ions. Others referred to 'free ions' without stating that the ions moved. A considerable number of candidates referred to 'mobile electrons' or 'mobile ions and electrons'.

(d) Many candidates wrote a balanced equation. Common errors included NaO or NaO_2 instead of Na_2O and hydrogen as an additional product.

Question A5

All parts of this question were generally well answered. Some candidates scored well in every part but fewer gained the marks for the equation in part **(b)(ii)** or the structure in part **(c)**.

(a) Many candidates gave a suitable oxidising agent. Others were not accurate enough in writing chemical names. Answers such as 'potassium magnate' are insufficient. A common error was to suggest 'steam'.

(b)(i) A majority of the candidates named a suitable metal to react with ethanoic acid. Copper was the most frequent incorrect answer. Fewer candidates gave the correct names of the products formed. Common errors included inaccurate naming of compounds e.g. ethnate instead of ethanoate, the omission of the co-product hydrogen and water instead of hydrogen.

(ii) A minority of the candidates wrote a correct balanced equation for the reaction of calcium carbonate with ethanoic acid. Others gained a mark for the correct formulae of carbon dioxide and water. A common error was to write calcium ethanoate as CH_3COOCa. A considerable minority of those who gave the correct formula for calcium ethanoate did not balance the equation.

(c) Some candidates wrote clear structures showing all atoms and bond. Others did not gain the mark because they omitted the O–H bond of the carboxylic acid group. Another common error was to draw a straight chain, sometimes bent round at the end due to the misconception that this was a branched chain.

(d) (i) A majority of the candidates gave the correct answer of condensation polymerisation. A significant minority suggested addition polymerisation. Others gave vague answers which either referred to the carboxylic acid group or referred to 'chemical polymerisation'.

(ii) Many candidates suggested a suitable advantage of a biodegradable polymer. Others wrote vague answers which referred to less pollution or recycling. A significant minority referred, incorrectly, to reusing the polymers.

Question A6

Many candidates gave good answers to each part of this question, especially to the energy profile diagram in part **(a)**. Others did not label the axes of the energy profile diagram or labelled them incorrectly. Parts **(b)** (how a catalyst works) and **(c)** (balance of carbon dioxide in the atmosphere) were less well answered.

(a) A majority of the candidates scored at least two of the three marks available. The commonest error was not to label the axes of the energy profile diagram or label them incorrectly. Incorrect labels included '*x*-axis and *y*-axis', 'energy change', 'temperature' (for the *y*-axis) and 'rate of reaction' (for the *x*-axis). Many candidates drew an activation energy hump unnecessarily. Few candidates drew an energy profile diagram for an endothermic reaction and many gained the mark for the enthalpy change. The commonest errors for the enthalpy change arrow were either not to draw it the full height between the reactants and products or to draw so that an activation energy hump was included.

(b) Most candidates realised that a catalyst lowers the activation energy. Fewer gained a second mark, many just referring to the catalysts being unchanged at the end or giving a definition of a catalyst in terms of increasing rate of reaction.

(c) Some candidates scored two marks. Others did not gain the mark for the emission of carbon dioxide into the atmosphere because they did not mention combustion. Many candidates confused the main issue by writing about respiration in plants as well as photosynthesis. The mark for the idea that the amount of carbon dioxide emitted during respiration (and combustion) is roughly balanced by that absorbed during photosynthesis was not often gained. Many statements were too vague e.g. 'so the respiration and photosynthesis is regulated' or 'some of the carbon dioxide taken in by photosynthesis is used for respiration'

Section B

Question B7

Many candidates gave a suitable observation in part **(a)** and nearly all the candidates gave the correct name for the salt in part **(b)**. The calculation in part **(c)** was generally well done. Fewer knew the tests for copper(II) ions using sodium hydroxide or ammonia in part **(d)** or were able to deduce the correct equation in part **(e)**.

(a) Many candidates gave one or two observations rather than a statement such as 'a gas is produced'. The commonest errors were to suggest either that a pink solid forms (rather than disappears) or that a blue precipitate forms.

(b) (i) Nearly all the candidates gave the correct name of the salt as either copper(II) sulfate or copper sulfate. A very small number of candidates disadvantaged themselves by writing incorrect oxidation numbers.

(ii) Many candidates gave a correct explanation of oxidation in terms of electron loss or increase in oxidation number. The commonest incorrect answers referred to addition of oxygen alone. A few candidates referred to oxidation being gain of electrons or referred to the sulfate ion rather than the copper.

(c) Many candidates gave the correct answer. The commonest error was to give the answer as $8.4\ dm^3$, by not taking into account the mole ratio of acid to sulfur dioxide. Other candidates divided twice and so obtained the incorrect answer $2.1\ dm^3$. A few candidates did not give the units or gave incorrect units.

(d) (i) Some candidates realised that the blue precipitate obtained on adding sodium hydroxide did not dissolve when excess sodium hydroxide was added. Others suggested that the precipitate dissolved and so did not gain the mark. A common error was to suggest that a white precipitate was formed.

(ii) Some candidates realised that on addition of excess ammonia, a dark blue solution is formed. Others thought that a dark blue precipitate was formed and so did not gain the second mark. A common error was to suggest that 'the precipitate darkens'. Some candidates just referred to a blue solution instead of a dark blue solution'. A number of candidates suggested an incorrect colour for the precipitate on addition of a small amount of ammonia even though they had got part **(i)** correct.

(e) Some candidates wrote a correctly balanced equation. Others either wrote the equation the wrong way round or did not balance it correctly. The commonest errors were lack of balance of $CuCl$ or incorrect balance of Cu (usually 2Cu).

Question B8

In part **(a)** most candidates gave a correct explanation of the reversible reaction symbol. Fewer candidates were able to give a suitable definition of exothermic in part **(b)** or to explain why a sealed container should be used in part **(c)**. In parts **(d)** and **(e)** some candidates were able to explain the effect of decreased pressure and increased temperature on the position of equilibrium. Others wrote confusing answers. Very few candidates gained marks for either part **(f)(i)** (distinguishing between strong and weak acids by experiment) or **(f)(ii)** (formulae of the two salts).

(a) Most candidates gave a correct explanation of the reversible reaction symbol. A few suggested that the symbol represented only the backwards reaction.

(b) Candidates often realised that the energy was released but fewer realised that 'thermic' refers to heat. A considerable proportion of the candidates tried to define exothermic in terms of bond making and bond breaking.

(c) Some candidates gave good answers relating to not wanting reactants or products to enter or leave the container. Others just referred to maintaining the pressure, temperature or volume. A common error was to suggest that heat should not be exchanged with the surroundings. This was not accepted as at this level, equilibrium is explained in terms of a closed system and not an isolated system.

(d) Some candidates identified the colour change correctly but fewer gained the mark for the explanation. Many did not mention the difference in the number of moles of gas or volume of gas on each side of the equation. A significant number of candidates tried to answer the question in terms of kinetic theory.

(e) Some candidates identified the colour change correctly but a considerable minority suggested that the colour gets lighter. More candidates gained the mark for the explanation compared with part **(d)**. Others either suggested that the reaction goes to the right even though they suggested the colour is brown or that the reaction goes to the left, even though they suggested that the colour gets lighter.

(f) (i) Hardly any candidates compared the acids at the same concentration. Some candidates gained a mark for suggesting a suitable experimental method. Others did not gain this mark because they suggested comparing rates (not enough indication about how the experiment is carried out) rather than the time taken to get a particular volume of gas (experimental). The better candidates compared the colour of universal indicator paper and gave a suitable result. Common errors included answers such as 'add water …the stronger acid is more ionised', reference to a bulb without mentioning a circuit and reference to gas collection without reference to time.

(ii) Very few candidates identified the formulae of the two salts. Some candidates gave the correct formula for potassium nitrate but unrelated non-nitrogen compounds were often given instead of the formula for potassium nitrite. Other common errors included HNO_3 or HNO_2 and writing names instead of formulae.

Question B9

Most parts of this question were well answered. The best answers were seen in part **(d)(i)** (calculation of empirical formula) and in part **(e)(i)** (definition of the term diffusion). Fewer candidates were successful in gaining marks in part **(c)** (environmental consequences of methane in the atmosphere) and in part **(e)(iii)** (explaining why diffusion can be used to separate gases).

(a) Many candidates gave a suitable use of methane. Some candidates wrote answers which were too vague to credit e.g. 'natural gas' or 'in cars'.

(b) A majority of the candidates referred to decomposing vegetation. Some just referred to decomposition which could refer to chemical decomposition. A considerable minority of candidates referred to global warming instead of giving a source of methane. Others wrote vague answers, referring to animals without qualification.

(c) Many candidates referred correctly to global warming or gave an effect of global warming. Others did not gain the mark because they did not describe an effect of methane but gave a statement about the properties of methane e.g. it is a greenhouse gas. Some candidates referred, incorrectly, to ozone depletion, photochemical smog or acid rain.

(d) (i) A majority of the candidates calculated the empirical formula correctly. The commonest errors were to use atomic numbers and to divide the mass of hydrogen by two or the mass of chlorine by 71.

(ii) Some candidates who scored two marks in part **(d)(i)** gained the mark for deducing the molecular formula. Others gave incorrect answers such as $2CH_2Cl$ or $(CH_2Cl)_2$.

(e) (i) Most candidates gave a good description of diffusion. Some candidates did not gain the mark because they did not mention particles. Others did not qualify their answers sufficiently and just mentioned 'movement of molecules' or 'mixing of particles'

(ii) Some candidates gave suitable explanations involving particles moving faster or having more kinetic energy. A significant number of candidates omitted the essential words particles or molecules. Others mentioned energy but omitted the essential word kinetic. A significant number of candidates discussed colliding particles in terms of rates of reaction rather that rate of diffusion.

(iii) Many candidates gained one of the two marks available, usually for the particles having different molecular masses. The commonest error was not to mention particles e.g. 'propane is heavier than methane'. Some candidates did not gain the second mark because they did not mention rates or speed of diffusion, often suggesting that all the methane diffused first, leaving the propane behind.

Question B10

Many parts of this question were well answered. In part **(a)** most candidates scored the mark for deducing the general formula and predicting the boiling point of hexane. Few candidates scored more than two marks for the description of fermentation in part **(b)**. In part **(c)** many candidates scored at least one mark for either the structure or name of the ester. Part **(d)** (particle motion and arrangement) was the least well answered part of this question, with many candidates confusing particle arrangement with the distance between particles.

(a) (i) Most candidates gave the correct general formula for alcohols. The commonest errors were either to omit a hydrogen atom ($C_nH_{2n+1}O$) or to write over-complex formulae.

(ii) Most candidates chose a boiling point from 154 °C to 164 °C. The commonest error was to give values of around 180 °C.

(b) Many candidates identified yeast and gave a suitable condition such as anaerobic or a temperature of 20–40 **°C.** Few suggested distilling the product. Common errors included hydrating ethene and use of an incorrect temperature. Some suggested, incorrectly, that the ethanol could be purified by filtration.

(c) Many candidates named the ester correctly although some did not name the compound accurately enough e.g. 'ethanote' or ‘ethate’ instead of ethanoate. Some candidates suggested ethyl butanoate instead of butyl ethanoate. Many candidates did not draw the structure of the ester correctly. Common errors included drawing butanoic acid, drawing ethyl butanoate, 5-valent carbon atoms, the inclusion of only one oxygen atom in the ester linkage and the addition of hydrogen between the C=O and –O– atoms.

(d) The best answers were comparative, referring to particles moving more slowly or coming closer together. Many candidates confused particle arrangement with the distance between particles. Others gave answers implying that at the lower temperature, ethanol would be solid. Many candidates, who referred separately to the gaseous ethanol and liquid ethanol, wrote rather vague statements and did not mention one or more of motion, arrangement or proximity in the liquid.

CHEMISTRY

Paper 5070/31
Practical Test

Key messages

Many candidates produced consistent titres but their results were not always in good agreement with the supervisor's titre.

The introduction of chromium(III) ions into the qualitative analysis proved problematic for some.

General comments

The overall standard was good and in general candidates performed equally well in both questions. It is vital that the advice issued in the confidential instructions, including checking the requirements, is followed. Centres running several sessions are requested to check and supply results for each session.

Comments on specific questions

Question 1

(a) Nearly all candidates completed the **Results** table correctly by recording readings to 1 or 2 decimal places, accurately subtracting them to determine the volumes of **Q** used and then ticking two or more titration results that did not differ by more than $0.2\,cm^3$. Securing at least two titres within $0.2\,cm^3$ of the supervisor's value proved challenging for some. There were still candidates who calculated the average volume of **Q** by using all their titres rather than just those ticked.

In the calculations that followed, candidates generally attempted all the parts and provided clear working. Some words of explanation along with the numbers would be useful at times particularly when changes or crossings out are made. A good number successfully answered every question.

(b) Apart from the few who did not consider the different units of volume in titre and concentration or used the pipette volume rather than average titre, candidates correctly calculated the number of moles of thiosulfate.

(c) Most divided the answer from **(b)** by 2 to calculate the number of moles of **P**.

(d) Many successfully scaled the number of moles of **P** in their pipette volume to $250\,cm^3$ but there were a few who believed they needed to use 24 000 in this calculation and/or the next.

(e) Despite the equation supplied, a significant number of candidates multiplied or divided their answer from **(d)** by 2.

(f) While this proved to be the most challenging question, a good number met its demands and scored both marks. Using 35.5 rather than 71 proved to be the most common error but there were some who were unable to scale the amount of chlorine in $50\,cm^3$ to $1\,dm^3$.

Question 2

It was rare to find a candidate who did not complete this question. There were some very good answers produced by well prepared and capable candidates. Marks were often lost because answers were incomplete and the colours of precipitates were incorrect.

Better performing candidates made full use of the qualitative analysis notes supplied on the last page of the examination paper. The terminology and method of reporting provided, are a model for the successful recording of observations.

R was ammonium chromium(III) sulfate; **S** was iron(III) chloride.

Test 1 Although most candidates reported a precipitate in **(a)**, a significant number thought it was green rather than white. Letting the solid settle makes it easier to see its true colour. Virtually all recognised that the precipitate remained when acid was added in **(b)**.

Test 2 There was some confusion over the colour of the precipitate produced here and in Test **3(a)**. Chromium(III) hydroxide is green and is insoluble in excess aqueous ammonia.

Test 3 Many reported that the precipitate dissolved in excess alkali but not all of these described the final solution as green. Some did not see any solid formed, presumably because the aqueous sodium hydroxide was added too quickly.

While ammonia was tested for and identified by numerous candidates, there were a few who reported other gases e.g. hydrogen, oxygen, carbon dioxide. The bubbling of the liquid caused by warming was often confused with the evolution of gas.

Test 4 As in test **1(a)**, the colour of the solution caused some to believe the precipitate formed was yellow rather than white. The solid was not always found to be insoluble in nitric acid.

Test 5 Most recorded the formation of a red-brown precipitate on the addition of alkali but not all noted it was insoluble in excess. A report that an insoluble red-brown precipitate is formed will only secure 1 of the 2 marks.

Test 6 The fading of the colour caused by the reduction with the ascorbic acid was observed by nearly all candidates. Many of these successfully recorded correct colours and/or precipitate when sodium hydroxide was added.

Test 7 Most scored both marks here for the red/brown colour of iodine which turns blue/black with starch.

Conclusions

It was rare to find a candidate who correctly identified all three ions in solution **R** even when all the evidence was present in the observations. While the mark for ammonium was most often awarded, there were candidates who correctly identified ammonia gas but did not report ammonium or instead suggested nitrate. The identification of sulfate had to be supported by a white precipitate in test **1(a)** or **(b)** which remained in acid. Chromium(III) proved to be the most problematic ion to secure the conclusion mark for, generally because the observations were incorrect. Iron(II) was sometimes offered as an alternative despite the dissolving of the green precipitate in excess alkali. As with all transition metal ions, it is important that the oxidation state or size of charge on the ion of the chromium is specified when it is identified.

While the oxidising agent in test **7** was recognised to be iron(III) by a considerable number, chloride and iodide were popular alternatives.

CHEMISTRY

Paper 5070/32
Practical Test

Key messages

Many candidates produced consistent titres but their results were not always in good agreement with the supervisor's titre.

The introduction of chromium(III) ions into the qualitative analysis proved problematic for some.

General comments

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While the oxidising agent in test **7** was recognised to be iron(III) by a considerable number, chloride and iodide were popular alternatives.

CHEMISTRY

Paper 5070/41
Alternative to Practical

Key messages

In questions that require candidates to plan an experiment, they should ensure that all the details that are requested are included in their answer if they are to gain full credit. They should also read the information provided that is designed to assist them in answering the question.

General comments

The Alternative to Practical Chemistry paper is designed to test the candidates' knowledge and experience of practical chemistry.

Skills including recognition and calibration of chemical apparatus and their uses, recall of experimental procedures, the ability to plan experimental investigations, handling and interpretation of data, drawing of graphs, calculations and analysis of unknown salts. The majority of candidates show evidence of possessing many of the aforementioned skills.

Most candidates show competency of plotting points accurately on graphs and joining the points as instructed.

Calculations are generally completed accurately using the appropriate significant figures, but candidates should be encouraged to show all their working.

Comments on specific questions

Question 1

(a) Most candidates correctly identified a tripod but many were unfamiliar with a crucible.

(b) Possible reasons for the mass of magnesium oxide being lower than expected were not well known. The magnesium may not have been completely reacted which could be rectified by heating to constant mass, or some of the magnesium oxide may have escaped from the crucible which a lid would prevent

(c) Many candidates gained partial credit for stating that the difference in relative atomic masses would cause the masses of oxide produced to be different but only a few scored full marks for showing how this would affect the number of moles of oxide produced.

(d) Safety glasses or goggles are the most important safety item when doing this experiment.

Question 2

Some very good answers were seen scoring full marks but many candidates did not read the question carefully and did not take note of what was required in their answer. All the information necessary to carry out the separation was given in the question. It was common for the sodium chloride solution to be heated until saturated and then allowed to cool, which would result in some sodium chloride remaining dissolved in the cooled solution. Some candidates separated the mixture without making any measurements and others did not show how they would use their results to determine the percentage of sodium chloride in the mixture.

Question 3

(a) The majority of candidates could identify the condenser. Many realised that the condenser turned a vapour or gas into liquid but only a minority mentioned that the liquid returned to the distillation flask.

(b) Most candidates gained some credit for their diagrams but did not attain marks because of insufficient care with the drawing. Common errors included incorrect placement of the thermometer, the direction of water circulation in the condenser being wrong or not shown and the distillation flask being left open or the receiver being closed.

(c) Many candidates did not realise that there was water in the final reaction mixture and that this would be the first compound to distil over.

(d) It was commonly recognised that effervescence would be observed in this reaction although some candidates did not notice that aqueous sodium carbonate was involved in the reaction and stated that the solid would dissolve.

Question 4

(a) The mass of the scrap iron was almost always correct.

(b) Few candidates stated that the reason for warming the flask was to increase the rate of reaction.

(c) The identity of the gas was generally correct but some confused the test for hydrogen using a burning splint with that for oxygen where a glowing splint is used. Other unacceptable descriptions of the splint e.g. lightening splint were seen and should be avoided.

(d) The use of a volumetric flask to make up solutions was not well known. Candidates should know that these flasks are very important and very accurate pieces of apparatus used in volumetric analysis. Most candidates knew that a pipette should be used to transfer the solution to the conical flask.

(e) Few candidates recognised that the colour at the end-point would be purple or pink due to the potassium manganate(VII) being in excess.

(f) The titration results were generally correct. The average volume should be calculated from the closest two titres. Some candidates used all three titres in calculating this volume.

(g)–(k) In the calculations errors are carried forward so that candidates are given credit for correct chemistry even if an error has been made in an earlier part. Candidates were penalised once if answers were given to fewer than three significant figures. Most candidates scored some calculation marks and many scored all of them.

Question 5

(a) A colourless solution indicates that a transition metal compound or ion is not present. Most candidates omitted the word ion or compound from their answer and did not score the mark.

(b) The majority of candidates correctly identified the two cations.

(c) The use of aqueous ammonia to distinguish between the two cations was well known.

(d) Most candidates knew the test to distinguish between chloride and iodide ions although some failed to give the correct colour of the iodide precipitate.

Question 6

(a) The table of temperatures was almost always correct.

(b) The points were usually plotted accurately and joined as instructed in the question. The lines were generally extended as required.

(c) Candidates usually used the graph correctly to determine the required masses.

(d) Most candidates correctly read the temperature at which the solubility of each compound is the same but many gave the mass reading at that temperature as the solubility, failing to realise that this mass needed to be multiplied by 10 to give the solubility in 100 g of water.

(e) From the graphs it can be deduced that the potassium chlorate(V) would not completely dissolve at this temperature resulting in a solution containing undissolved solid whereas the sodium chloride would completely dissolve resulting in a colourless solution. Many candidates simply stated the solubility of the salts rather than describing the appearance of the contents of the tubes.

(f) A significant number of candidates gained partial credit for recognising that as the temperature increased the solubility of both salts increased but few stated that the solubility of potassium(V) chlorate increased more than that of sodium chloride.

CHEMISTRY

Paper 5070/42
Alternative to Practical

Key messages

In questions that require candidates to plan an experiment, they should ensure that all the details that are requested are included in their answer if they are to gain full credit. They should also read the information provided that is designed to assist them in answering the question.

General comments

The Alternative to Practical Chemistry paper is designed to test the candidates' knowledge and experience of practical chemistry.

Skills including recognition and calibration of chemical apparatus and their uses, recall of experimental procedures, the ability to plan experimental investigations, handling and interpretation of data, drawing of graphs, calculations and analysis of unknown salts. The majority of candidates show evidence of possessing many of the aforementioned skills.

Comments on specific questions

Question 1

(a) (i) Candidates must mention a flame or something that is burning when referring to the test for hydrogen gas. A glowing splint was seen very occasionally. Other unacceptable descriptions of the splint e.g. lightening splint were seen and should be avoided.

It is far better to describe the test and observation for the test for hydrogen as **burning splint pops.** No other words are required.

(a) (ii) The conical flask was sometimes identified only as a flask or as a volumetric flask. Most candidates correctly identified the gas syringe.

(a) (iii) This was almost always correct. A reading of 40.6 was seen very occasionally.

(b) (i) Several candidates referred to 'the tube' without specifying which tube they were referring to. The essential part of the answer was that the gas can only be dried if it comes into contact with the drying agent. The drying agent was occasionally referred to as water.

(b) (ii) Several candidates referred to 'the tube' without specifying which tube they were referring to. In this case the gas would not be dried because it would not come into contact with the drying agent.

Question 2

(a) Only a minority of candidates recognised that the build-up of pressure was a potential safety hazard.

(b) (i) This was answered extremely well.

(b) (ii) This was answered extremely well.

(b) (iii) Only a slight majority of candidates realised that the temperature would start to increase again when all the propanoic acid had distilled over. It is very important that the spelling of propanoic is correct so as not to risk confusion with propenoic acid.

(c) Many candidates mentioned the electric heater which was already shown in the diagram. Safety glasses/goggles were correctly identified by a minority of candidates. Googles was seen almost as regularly as goggles.

Question 3

(a) It is recommended that candidates plan what they are going to write. It was common to see things like '*First* heat the crystals' followed by '*Before this*, measure the mass of crystals on a balance'.

Candidates often started with a solution of copper(II) sulfate despite being informed that they were provided with copper(II) sulfate crystals and went on to include methods of obtaining crystals from an aqueous solution.

Those who progressed down the correct route of heating to dryness often omitted to mention how they would decide when to stop heating. Heat to constant mass was the ideal explanation, although it was rarely seen.

'Subtraction' was mentioned as the method of obtaining the mass of water lost. However candidates needed to make it clear what was being subtracted from what. The method used to calculate the percentage after the experiment was finished should ideally have been written as an equation. References to 'mass of the copper sulfate' often did not make clear whether this was the original crystals or the anhydrous product.

Many candidates referred to M_r and or moles which was not relevant to the question.

(b) As in **(a)** many assumed that a solution was the starting material and that crystallisation was being carried out. The instruction 'You can assume that all her weighings were read and recorded correctly and that her calculation was correct' was often ignored. The main reason for the error was that the crystals were not heated to constant mass, and therefore some water remained in the crystals. This was only realised by a minority of candidates.

Question 4

(a) Almost all the candidates carried out this subtraction correctly.

(b) Although the majority of candidates scored this mark, some described a test for carbon dioxide gas which was not requested. Very few mentioned that the solid dissolved which was allowed as an alternative to effervescence. This type of question asks for an observation and does not require the name of the gaseous product, nor the fact that a gas is given off.

(c) (i) Only some were able to name this important piece of apparatus used in volumetric analysis. Measuring cylinder and burette were common answers, neither of which is used as a vessel to make solutions.

(c) (ii) There was a wide variety of answers to this question suggesting only a minority consider a bulb or pipette filler as a safety item.

(d) The majority of candidates knew the colour change of methyl orange at the end-point of this titration.

(e) The vast majority of candidates scored full marks for the table. Only a small number read the burettes 'upside down'.

(f)–(k)(ii) All parts of the calculation were carried out extremely well by the majority of candidates. Occasionally there was a rounding error or fewer than three significant figures were given to numerical answers.

Question 5

(a) The majority of candidates knew what the correct reagents were for the sulfate test and also knew that a white precipitate was the expected positive observation. Those who used formulae to identify reagents made occasional errors.

(b) (i) This was well answered by the majority of candidates. Some wrote Fe^{2+} in both of the last two spaces.

(b) (ii) This was also well answered by the majority of candidates, Some candidates mixed up the colour changes for Fe^{2+} and Fe^{3+}. Many candidates gave correct answers in **(b)(i)** and **(b)(ii)** for Cr^{3+}, a recent addition to the syllabus.

Question 6

(a) The points were often plotted correctly and the curve, although difficult, was often smoothly drawn. Only a small number used thick lines or joined some or all of the points together with a ruler. The most common error was to ignore the instruction to extend the line to cross the *y*-axis.

(b) (i) The pH of 25.0 cm^3 1.0 mol/dm^3 sodium hydroxide is obtained by reading off the pH value where the line crosses the *y*-axis because this represents the pH when the sodium hydroxide is present on its own before any acid is added. Those who did not extend the line in **(a)** could not achieve this mark.

(b) (ii) A large majority of candidates scored this mark.

(c) (i) A minority of candidates recognised that the end point was at pH 7, or at any volume where the pH changed rapidly for the addition of a small volume of acid.

(c) (ii) Any volume that corresponded to the answer of **(c)(i)** was accepted.

(d) Only a small number of candidates managed this calculation. There were no common errors.

(e) This common question did not score highly. Many candidates described a titration, even though there were provided with aqueous sodium sulfate. Therefore there was no requirement to make the solution by titration. Others used inappropriate chemicals, e.g. sodium.

Evaporation to dryness is an inappropriate method of producing crystals.

The question asks for pure, dry crystals Therefore a description of drying is required; the statement ‘dry the crystals’ is not sufficient.