CHEMISTRY

Paper 5070/11
Multiple Choice

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

General comments

Questions 1, **4**, **10**, **14**, **and 37** were found to be easier.

Candidates found **Questions 7**, **9**, **26** and **30** challenging. There was evidence of guessing in **Questions 9**, **15**, **20**, **22**, **28** and **30**.

Comments on specific questions.

Question 7

Option **A** was a common incorrect choice. Candidates simply saw that there are two isotopes of chlorine and ignored the formula of the compound.

Question 9

Option **B** was chosen by the majority of candidates, including those who performed well in the rest of the paper. Perhaps candidates focused on the formation of the chloride and ignored the hydrochloric acid reagent. Alternatively, they may have overlooked the formation of hydrogen gas in the reaction.

Question 15

There was evidence of guessing for this question as candidates were either not able to do the calculation or did it incorrectly.

Question 17

Options **B** and **C** were common incorrect choices. Some candidates find questions where they are required to link different parts of the syllabus to answer the question particularly challenging. Perhaps another challenge is the use of X and Y for the names of the compounds.

Question 18

Candidates choosing option **C** did not appreciate that –50 becomes +50 in the reverse reaction.

Question 20

Options **C** and **D** were popular incorrect choices. There was also evidence of guessing as candidates chose distracters based on reversible reactions rather than rate of reaction.

Question 22

Options **B** and **C** were commonly chosen. Just over half of candidates thought the mixture became paler or colourless, perhaps because they had the equilibrium shifting the wrong way or they thought it could be due to dilution effects.

Question 23

Candidates who selected option **A** had the correct oxidation state for manganese but did not have the chloride oxidised.

Question 26

Many candidates chose options **D** or **C**. This suggests that section 9.4(a) in the syllabus was not well understood by candidates.

Question 28

There was evidence of guessing by some candidates. Many chose options **A** and **B**, which have lead chloride as a solution. This suggests candidates had not learnt 7.2(b) of the syllabus.

Question 30

There was evidence of guessing by some candidates. It is possible that they did not use the Periodic Table to identify element Y. Many chose option **A**, meaning sodium chloride is a liquid at room temperature.

Question 31

While option **C** was the most common answer, some candidates who performed well overall chose option **A**. 8.2(c) of the syllabus clearly states the use of both argon and neon in light bulbs.

Question 32

Many candidates chose option **B**. Candidates did not link the thermal stability of the metal carbonate to the relative reactivities of the metals.

Question 35

While option **B** was the most common answer, some candidates who performed well overall chose option **A**. It is possible that these candidates worked out C_6H_{12} needs exactly nine moles and that C_6H_{14} needs more and did not then write out the equation for $C_6H_{14}O$, assuming it would also be more.

Question 40

Candidates selecting option **D** did not understand that atoms/groups of atoms do not switch between carbon atoms during addition polymerisation.

CHEMISTRY

Paper 5070/12
Multiple Choice

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

General comments

Candidates found **Question 6** easy.

Candidates found **Question 1** challenging. There was evidence of guessing for **Questions 1**, **7**, **9**, **15**, **20**, **21**, **24**, **26**, **32** and **37**.

Comments on specific questions.

Question 1

Options **B** and **C** were common incorrect choices. The majority of candidates chose one of these two answers. Both have the stop-clock, but neither has both pieces of equipment needed to measure out the reagents.

Question 7

Candidates who chose option **A** saw that there are two isotopes of chlorine but ignored the formula of the compound.

Question 9

Option **D** was the most commonly chosen answer. The forces in ionic compounds are strong, but candidates are mistaken in the forces being intermolecular.

Question 15

There was evidence of guessing here as candidates were either not able to do the calculation or did it incorrectly.

Question 20

There was evidence of guessing here. The item requires candidates to select the appropriate equipment, but this time for an experiment they are unlikely to have done.

Question 21

There was evidence of guessing among candidates who performed less well overall. These candidates did not have a good understanding of 6.1(f) of the syllabus.

Question 24

There was evidence of guessing which indicates candidates did not have a good understanding of 6.2(d) of the syllabus. Option **A** was chosen more than the key with candidates correctly identifying that iodide ions are oxidised, but not that the formation of iodine gives a brown solution.

Question 26

There was evidence of guessing among candidates who performed less well overall. Option **D** was chosen as often as the key. Candidates have made two errors, linking hydrochloric acid not sulfuric acid to double the volume of gas and the highest pH to a mineral rather than organic acid.

Question 32

There was evidence of guessing among candidates, indicating that candidates did not have a good understanding of 9.2(a) and (i) of the syllabus.

Question 37

There was evidence of guessing among candidates who performed less well overall. These candidates did not have a good understanding of 11.4(b) and (f) of the syllabus.

CHEMISTRY

Paper 5070/21
Theory

Key messages

- After completing an answer, it is advisable for candidates to read the question again to ensure they have answered all of what is being asked. This will help ensure that numerical answers are given to an appropriate number of significant figures and that written responses cover all aspects of the question.
- Candidates need more practice constructing balanced equations, particularly ionic equations.
- Many candidates did not understand chemical bonding and the drawing of structures of organic compounds. Recall of the blast furnace was limited. Metallic structure was very confused.

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.

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

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

Some candidates had a clear understanding of bonding and could explain the properties arising from specific types. Answers from others were contradictory with intermolecular forces in ionic bonding and arrays of protons in metallic bonding.

Question 7 was the least popular ***Section B*** question.

Comments on specific questions

Section A

Question 1 – Compounds

(a) Reaction of carbonates with acid was very well known. '$NaOCOCH_3$' and 'NH_4Cl' were common.

(b) Formation of ammonia was well known. 'Na_3PO_4' was a common response.

(c) Higher attaining candidates recognised the formation of SO_2 from K_2SO_3. '$NaOCOCH_3$' and 'Na_3PO_4' were popular responses. A significant number omitted this question.

(d) The insoluble compound was recognised by candidates who performed well. '$MgNO_3$' was a common response.

(e) Higher performing candidates recognised the 3-anion. 'K_2SO_3' was a common response.

(f) Candidates who performed well chose the reducing agent. '$BaSO_4$' and 'K_2SO_3' were common responses.

Question 2 – Elements in Group V

(a) Almost all candidates gave the correct electronic configuration. A very small number gave 2.8.6.

(b) The majority of candidates appreciated that only boiling point showed a trend. Some candidates reversed melting point and boiling point.

(c) Some candidates appreciated that the temperature was between the melting point and the boiling point. Many candidates either rewrote the stem of the question or only discussed the temperature in relation to the melting point or the boiling point.

(d) (i) Many candidates drew single or double bonds between the atoms and those that drew a triple bond often omitted the non-bonding pairs of electrons.

(ii) Candidates found this very challenging with many discussing weak covalent bonds or quoting the structure without discussing the weak forces between the molecules.

(e) The physical properties of metals were very well known. A small number gave high melting point and high boiling point as two separate answers or quoted chemical properties including reaction with acids.

(f) Higher attaining candidates performed the calculation correctly and gave their answer to two significant figures. Many candidates divided by 14 instead of 28 when determining the number of moles. Most candidates showed their working and so an error carried forward could be applied where appropriate. Many candidates gave their answer to more than two significant figures.

Question 3 – Organic Chemistry

(a) Many candidates identified all three products correctly. Some gave incorrect formulae instead of names and some reversed **A** and **C**. Popular responses also included hydrogen for **A**, ethanol for **B** and a hydrocarbon for **C**.

(b) Better performing candidates appreciated the oxidation product. The most common incorrect response was 'butane'; 'alcohol', 'butanol' and 'ethyl butanoate' were also common.

(c) Higher performing candidates derived the name of the ester; 'ethyl butanoate' was the most common incorrect response. The structure proved challenging with many penta-valent carbon atoms, COOH-linkages or butanoic acid drawn.

Question 4 – Atomic Structure and Bonding

(a) Most candidates calculated the number of neutrons correctly. '35' was a common incorrect response.

(b) The number of electrons was well known. The most common answer was '17' where candidates did not notice the – sign on the ion.

(c) Many candidates derived the symbol correctly. 'K^{+}' was the most common incorrect response and some gave the mass number as 39.

(d) Formation of the ion was well known. Common incorrect responses included not specifying the number of electrons lost, K^{+} losing electrons and the atom gaining one electron.

(e) (i) Candidates found this very difficult. Where attraction between the ions was discussed, this was often contradicted by a discussion of strong intermolecular forces or strong molecules. Strong bonds unqualified and 'strong covalent bonds' were also common.

(ii) Higher attaining candidates gave at least one property which was often 'soluble in water'. Incorrect responses included 'conduction of electricity' with no state specified and 'coloured'. Many gave metallic properties for potassium or general metallic properties.

Question 5 – Equilibrium and Iron Compounds

(a) (i) Some candidates gave a correct prediction and explained it. Many discussed the movement of the equilibrium without connecting it to the amount of hydrogen in the equilibrium mixture. Increase was very common and some discussed rate rather than equilibrium.

(ii) Candidates found this more challenging than **(a)(i)**; 'stays the same' was the most common incorrect response. Where candidates had the correct prediction, many did not include gas in their explanation. Many discussed the movement of the equilibrium without connecting it to the amount of hydrogen in the equilibrium mixture or discussed rate rather than equilibrium.

(b) (i) Candidates found the ionic equation very difficult. Many had Fe^{2+} as a reagent, included spectator ions or used molecular formulae. Where ionic equations were written, many were not balanced and state symbols were often omitted.

(ii) Many candidates recalled the test for iron(II) ions. 'Flame test' and 'add acid' were popular incorrect responses.

(iii) Many candidates calculated the relative formula mass correctly. Common incorrect responses included '152', '182' and '241'.

(iv) More successful candidates calculated the value correctly. '12.5' and '10.9' were popular responses.

(c) Candidates found this difficult. Common incorrect responses included 'iron', 'sulfur', 'SO_2' and 'SO_3'.

(d) The blast furnace was not well known. Higher attaining candidates gave the correct reactions, usually accompanied by balanced equations. The most common errors were the reaction of carbon monoxide with oxygen to form carbon dioxide and the reaction of carbon dioxide with oxygen to form carbon monoxide. Many omitted the most essential reaction, the reduction of iron oxide by carbon monoxide.

Section B

Question 6 – Carbon Monoxide and Nitrogen Monoxide

(a) Candidates found this difficult with many discussing nitrogen in the fuel being oxidised. 'Nitrogen dioxide reacting with nitrogen' and 'nitrogen dioxide reacting with carbon monoxide' were also very common responses.

(b) (i) Many candidates discussed the gain and loss of oxygen and correctly ascribed them to oxidation and reduction. The most popular non-creditworthy answers were 'CO losing electrons' and 'NO gaining electrons'.

(ii) Higher attaining candidates discussed the exothermic making of bonds outweighing the endothermic breaking of bonds. The most common error was bond making needing energy. Some discussed numbers of bonds.

(iii) The effect of temperature on rate was quite well known. Answers were sometimes vague, discussing energy rather than kinetic energy, frequency of collisions rather than successful collisions and not mentioning particles. Very few considered the number of particles with energy equal to or higher than activation energy.

(iv) The role of a catalyst was well known. Other responses included 'increasing energy of the particles' and alternative pathway with no reference to activation energy.

(v) Candidates found this very challenging. Many discussed success of collisions or chances of collisions rather than increased collision frequency or that the particles had more energy. Very few candidates appreciated that there were more exposed particles able to react.

Question 7 – Aluminium

This was the least popular of the ***Section B*** questions.

(a) The uses of aluminium were not well known with many repeating the question stem. 'Low weight' was common instead of low density.

(b) Some candidates recalled that aluminium forms an oxide layer on its surface but few explained that the layer is impermeable. Many discussed the 'layer being unreactive' or 'stopping the iron reacting' without explaining how.

(c) Candidates found this very challenging and a significant number omitted the question. Diagrams were often unlabelled, or the circles labelled protons. Some diagrams had the ions too far apart or not regular and had the electrons around the outside. Some drew an ionic structure. Those that appreciated the attraction between the positive ions and electrons being responsible for the bonding usually omitted to describe them as strong.

(d) Some candidates gave a correct ionic equation for the cathode and better performing candidates gave the equation for the anode as well. Common errors included '$3Al$' or 'Al_3' as the product at the cathode, OH^- equation at the anode or an incorrect number of electrons and electrons on the incorrect side of the equation for each electrode.

(e) Many candidates calculated the numbers of moles of aluminium and sulfuric acid and then compared these two values without considering the stoichiometry of the equation. Common errors included dividing the mass of aluminium by 54, calculating the mass of sulfuric acid and then comparing masses of aluminium and sulfuric acid rather than moles.

Question 8 – Organic Chemistry

(a) Propene was very well known. 'Ethene', 'butene' and 'propane' were common responses.

(b) Candidates found this challenging. The non-branched alkene was better known that the branched. The branched alkene was often the unbranched alkene drawn going round a corner. There were also many penta-valent carbon atoms or missing hydrogens in the structures.

(c) The test for unsaturation was well known. Some reversed the outcomes of the test or used $KMnO_4$ or litmus paper or described cracking.

(d) (i) Candidates found this very challenging. Many understood the process of cracking and described it without giving any reasons why the process is important.

(ii) Many candidates calculated both the empirical formula and the molecular formula correctly. Some candidates divided by 2 for hydrogen or gave 1 : 2 as the empirical formula followed by CH_2 for the molecular formula. 'C_6H_{12}' was a common response for the molecular formula.

Question 9 – Ammonia and Fertilisers

(a) Many candidates gave a correctly balanced equation incorporating the equilibrium arrow. 'N', 'H' and 'H_3' were seen commonly in equations as candidates attempted the balancing.

(b) (i) The majority of candidates chose nitric acid. 'Hydrochloric acid' was the most common incorrect response.

(ii) Many candidates calculated the percentage correctly. The most common error was dividing 14 by 80 rather than 28 for the two nitrogens in the compound.

(c) (i) The term eutrophication was well known. 'Erosion' was a popular response.

(ii) Candidates found this very challenging and mainly discussed nitrate fertilisers increasing growth rate of plants. A very small number appreciated that the question wanted to know why nitrate fertilisers increase the situation more than other fertilisers and so attempted a comparison. A significant number omitted the question.

(d) (i) Use of calcium hydroxide was well known. Incorrect responses included 'raising acidity' and 'lowering pH'.

(ii) Candidates found the equation very challenging with few giving ammonia as a product. Few could then discuss the loss of ammonia or nitrogen from the soil; 'acidifying the soil' was the most common response.

CHEMISTRY

Paper 5070/22
Theory

Key messages

- Many candidates showed their working out in calculations. This is good examination practice as often the working out is more important than the final answer.
- Candidates must not use ideas about rate of reaction and collision theory when answering questions about chemical equilibrium. Candidates must also distinguish between the equilibrium composition and the position of equilibrium.
- Candidates often had problems when constructing ionic equations or ionic half-equations and did not write the correct formulae for the species involved or did not balance the charge.
- Candidates must use the correct terminology when answering questions on structure and bonding. It is important to distinguish between particles (atoms, ions and molecules) and attractive forces (metallic bonds, ionic bonds, covalent bond and intermolecular forces). It is also important to give an indication of the strength of the attractive forces e.g. weak intermolecular forces and strong covalent bonds.

General comments

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

In ***Section B***, **Question 7** was the most common and **Question 10** was the least popular. Only a small proportion of the candidates answered all four questions.

Comments on specific questions

Section A

Question 1

Some candidates did not attempt one or more of these questions.

(a) Many candidates recognised that $KMnO_4$ is purple in colour.

(b) Some candidates recognised that $Ba(NO_3)_2$ forms a white precipitate with aqueous sodium sulfate. A common incorrect answer was $AgCl$.

(c) Many candidates recognised that KI gives a brown solution with chlorine.

(d) Some candidates recognised that $AgCl$ is prepared in a precipitation reaction. Common incorrect answers were KI and $Ba(NO_3)_2$.

(e) Many candidates recognised that Na_3N contains an anion with a charge of –3. The most common incorrect answers were NH_4Cl and K_2SO_3.

(f) Some candidates recognised that $KMnO_4$ is used to test for a reducing agent. The most common incorrect answers were KI, K_2SO_3 and $AgCl$.

Question 2

(a) Most candidates gave the correct electronic configuration for sulfur. The most common misconception was to give an electronic structure with 32 electrons.

(b) Most candidates predicted the density of polonium. The most common correct values were between 8.0 and 8.5. Most of the incorrect answers were below the density of tellurium.

(c) Most candidates deduced that sulfur was a liquid at 200 °C; a correct explanation was also needed for credit to be awarded. The best answers referred to 200 °C being between the melting point and the boiling point. A common misconception was to refer to either the melting point of sulfur or the boiling point but not both. Common incomplete answers were that 'sulfur is a liquid since it has already melted' or 'sulfur had not yet boiled'.

(d) (i) Many candidates were able to draw the correct dot-and-cross diagram. The most common misconceptions were to draw a single bond or a triple bond between the two oxygen atoms. Only a small proportion of the candidates drew a double bond and then included 6 other outer electrons around each oxygen atom.

(ii) Many candidates mentioned the presence of intermolecular forces but often these answers were either incomplete or incorrect. Incomplete answers typically did not mention that the intermolecular forces were weak. Incorrect answers often referred to intermolecular forces between atoms or between bonds. Some candidates mentioned covalent bonds in their answer but did not make it clear if it was the covalent bond or the intermolecular force that was overcome during melting. A small proportion of the candidates referred to the presence of weak covalent bonds to explain the low melting point.

(e) (i) Many candidates found this question challenging and did not give the correct answer of SeO_2. The most common misconception was to give the formula as Se_2O_4 but answers such as SeO, SeO_4 or Se_2O were also given.

(ii) Many candidates did not appreciate that selenium(IV) oxide in water makes an acidic solution and as a result gave colours ranging between purple to green. A common misconception was to state that the oxide was alkaline. Candidate needed to link the correct colour with selenium being a non-metal oxide but many just stated it was an acidic oxide. A significant proportion of the candidates did not attempt this question.

(f) Some candidates were able to give the correct answer of 23 dm^3 and included the correct steps of calculating the moles of oxygen, using the molar volume of oxygen and finally rounding to two significant figures. The most common misconception was to use the molar mass of oxygen as 16 g rather than 32 g and as a result got an answer of 45 dm^3. Candidates should be advised to only round up or round down at the very end of the calculation to avoid rounding errors.

Question 3

(a) Candidates should follow the instructions in the question. In this question, the names of the unknown substances were required and a significant proportion of the candidates gave either the formula only or both name and formula. Candidates often appreciated that **A** was hydrogen and **D** was water. Candidates found naming **B** challenging and a common misconception was to identify **B** as magnesium carbonate. Candidates needed to be careful to give the correct name for **B**; answers such as magnesium butonoate or magnesium butenoate were not given credit.

(b) Some candidates gave the correct name for the ester **E,** but butyl ethanoate was a common misconception. Most candidates drew structures that showed all the atoms and all the bonds and mirrored the structure shown in the question. The structures of butanoic acid and ketones were sometimes drawn instead of esters. A significant proportion of the candidates did not attempt this question.

(c) The term weak acid was well known by most candidates. The only misconceptions were to use dissolving rather than dissociating and to refer to pH values or the number of hydrogen ions in solution.

Question 4

(a) Most candidates recognised that the nucleon number was 79. The common incorrect answers were 44 and 114.

(b) Most candidates deduced that the number of electrons in the bromide ion was 36. The most common incorrect answer was 35.

(c) Candidates gave a variety of answers for another isotope of calcium. One common misconception was to give the formula for a calcium ion rather than a calcium atom. Some candidates changed the proton number rather than the nucleon number when writing their symbol.

(d) Most candidates appreciated that a calcium atom loses two electrons to form a calcium ion. A small proportion of the candidates answered a different question, namely how a calcium atom is formed from a calcium ion.

(e) (i) Many candidates referred to the presence or lack of electrons that move rather than the correct charge carrier. Only the best answers mentioned that ions are fixed in position in solid calcium bromide but move in molten calcium bromide. A common misconception referred to free ions rather than focusing on the mobility of ions.

(ii) Candidates often referred to high melting and boiling points but did not give a second suitable property. Answers that mentioned calcium bromide being soluble often did not mention the solvent in their answer. Some candidates referred to calcium carbonate being insoluble in organic solvents which was credited. A significant proportion of the candidates gave properties of a metal rather than of an ionic compound.

Question 5

(a) (i) Some candidates did not appreciate that the question asked about the amount of ethanol in the equilibrium mixture and gave an answer that referred to the shift of the position of equilibrium. The explanation was only credited if the prediction was correct. Candidates often referred to the reaction being exothermic although some explanations were based on ideas about rate of reaction rather than equilibria. Candidates need to ensure that they refer to the forward reaction being exothermic or the backward reaction being endothermic rather than just stating the reaction is exothermic.

(ii) Some candidates did not appreciate that the question asked about the amount of ethanol in the equilibrium mixture and gave an answer that referred to the shift of the position of equilibrium. The explanation was only credited if the prediction was correct. Candidates with the correct prediction often referred to the reactants having more moles than the products but did not mention that this idea refers to gases.

(b) The equation for fermentation was not well known and often water was given as a product and sometimes the equation for respiration was given. The conditions needed for fermentation were well known with candidates often quoting the presence of yeast, anaerobic conditions and a correct temperature. Candidates very rarely stated the need for water or the use of aqueous glucose. Some candidates confused the conditions for the hydration of ethanol of ethene with those for fermentation.

Question 6

(a) Candidates found this ionic equation very challenging and often missed out the hydrogen ion or used the incorrect formula for an aluminium ion. Other candidates did not attempt the question. Many candidates included sulfate ions in their equations. The state symbols were well known but were only credited if the equation used the correct formula or symbols.

(b) A small proportion of the candidates confused ammonium ions for aluminium ions and mentioned the formation of ammonia gas. Many candidates chose aqueous sodium hydroxide and often gave the correct observations with excess aqueous sodium hydroxide. Other candidates gave aqueous ammonia and some gave both aqueous ammonia and aqueous sodium hydroxide. A small proportion of the candidates confused ammonia with ammonium ions as the reagent of choice.

(c) Candidates often gave the correct answer of 18 and supported their answer by working out the relative formula mass for aluminium sulfate. A significant proportion of the candidates did not work out this formula mass correctly or left the question blank.

(d) The term alloy was well known and many answers referred to a mixture of metals. The most common misconception was to refer to a combination of metals or a compound rather than a mixture.

Section B

Question 7

This was the most popular question of the optional questions.

(a) Most candidates referred to global warming or the greenhouse effect.

(b) Most candidates referred to acid rain. A misconception was that it is linked to ozone depletion.

(c) (i) Many candidates appreciated that a powder has a greater surface area, although a common misconception was that the actual particles had a larger surface area. Candidates often mentioned the idea of more collisions but did not mention the idea of collision frequency in their answers. Answers that referred to more exposed particles were also credited.

(ii) The idea that the kinetic energy of the particles decreases was more likely to be given than the particles are moving slower. Some candidates referred to particles gaining less kinetic energy and this was not given credit since they do not gain kinetic energy but lose kinetic energy because the temperature has decreased. Candidate sometimes qualified their answers about more collisions by using successful or effective. References to more successive collisions or more efficient collisions were not credited.

(d) (i) The idea that sulfur dioxide gains oxygen was recognised by many candidates. Other candidates used ideas about oxidation state or electron transfer but these were not credited unless they referred to sulfur rather than sulfur dioxide in the answer e.g. ‘sulfur loses electrons’ rather than ‘sulfur dioxide loses electrons’.

(ii) Many candidates gave good answers and referred to bond breaking being endothermic and bond making being exothermic. The answers then went on to compare the size of energy absorbed with the energy released. Some candidates tried to relate their answers to the equation given and referred to 'the reaction making sulfur trioxide involving bond making so the reaction was exothermic’. These answers did not mention bond breaking at all and so were not credited.

(iii) The idea that the activation energy was lowered was given by many candidates, although some candidates thought catalysts give particles energy. Reference to an alternative pathway was not credited unless it was clear that the activation energy was decreased.

Question 8

(a) Some candidates gave explanations that were suitable for barrier protection rather than sacrificial protection. The best answers compared the reactivity of zinc and iron and appreciated that zinc reacts with oxygen and water instead of iron. A common misconception was to refer to zinc rusting to stop iron rusting.

(b) (i) Candidates found this question challenging and often answers lacked the clarity and precision needed. Diagrams were often incomplete with either labels missing or incorrect labels. The positive ions were often drawn too far apart so the drawing did not resemble closely packed zinc ions. Some answers did not have the electrons integrated within the close packing but included them only on the outside. Only the best answers mentioned the strong attraction between the positive ions and the sea of delocalised electrons. A significant proportion of candidates mentioned intermolecular forces or even zinc molecules.

(ii) Many candidates appreciated that electrons were able to move. It was not sufficient just to refer to delocalised electrons; there had to be a positive statement that the electrons were moving.

(c) Candidates were more likely to get the cathode ionic equation correct than the anode ionic equation. Candidates often did not balance the anode equation in terms of atoms and/or charge.

(d) Candidates used a variety of different approaches to answer this question. The best answers showed all the working out and ended with a statement explaining why the hydrochloric acid was in excess.

One approach was to calculate the amount of zinc, the amount of hydrochloric acid that reacts with the zinc and compare this with the amount of hydrochloric acid provided.

An alternative approach used the amount of hydrochloric acid provided and then calculated the amount of zinc needed to react with this acid and compare this with the amount of zinc provided. A significant proportion of the candidates did not use the mole ratio of the equation.

Other approaches involved calculating the mass of zinc needed to react with the provided hydrochloric acid or calculating the concentration of 50.0 cm^3 of hydrochloric acid needed to fully react with the zinc.

A common misconception was to compare the mass of zinc with the mass of hydrochloric acid present.

Question 9

(a) Most candidates drew structures showing all the bonds and all the atoms. A significant proportion of the candidates drew two structures that were both butane by having one structure as the straight chain and the other with a bent straight chain. Other candidates drew cyclobutane instead as the second structure.

(b) The formula $C_{12}H_{26}$ was deduced by most candidates, often supported by working out that included the general formula.

(c) Candidates needed to refer to petroleum being pre-heated, the use of a fractionating column and the different boiling points of the fractions. The idea of the petroleum being pre-heated was poorly expressed and a common answer was to refer to the petroleum being heated in the fractionating column. Some candidates confused bubble caps with columns and referred to different fractions being collected in different columns. The idea that the separation depends on boiling point was well known by the candidates, although some candidates referred to melting point. Only a small proportion of candidates confused cracking with fractional distillation.

(d) (i) The most common answers were high temperature, high pressure and/or the use of a catalyst.

(ii) Only a small proportion of candidates were able to complete the calculation and obtain the molecular formula. Many candidates did not appreciate that the molecular formula must have four carbon atoms because of the information from **(i)**. A greater proportion of candidates calculated the empirical formula. Some candidates did not give an empirical formula but just stated the ratio of atoms. A common misconception was to use the molar masses of H_2 and Cl_2 to work out the amount of hydrogen and chlorine. Other candidates used the proton number and some inverted the expression for the amount in moles. The best answers presented the calculation in a tabulated form.

Question 10

This was a the least popular question.

(a) Some candidates were able to balance the equation. A significant proportion of these candidates used fractions to balance the equation.

(b) (i) Some candidates gave potassium oxide or potassium but these were not credited.

(ii) The best answers described the titration between the alkali in **(i)** with dilute nitric acid. Candidates sometimes missed out using an indicator and gave the incorrect colour change for the indicator. Candidates often just stated that the titration is repeated without stating that the indicator is not needed and the same volumes of acid and alkali have to be used. A common misconception was to describe the experimental procedure for an insoluble base and an acid.

(iii) Most candidates who calculated the correct molar mass were able to calculate the percentage by mass of nitrogen. A small proportion of the candidates worked out the percentage by mass of potassium rather than nitrogen. Better performing candidates showed their working out.

(c) (i) The most common pollutant given was plastic. A large variety of pollutants were accepted but answers such as ‘chemical waste’ or ‘factory waste’ had to be qualified by the name of the waste. Some candidates gave carbon dioxide and this was not credited.

(ii) The names of three processes were required. Some candidates contradicted their answers by stating the name of a process and then giving a contradictory description. Sedimentation, filtration and screening were considered to be the same because they remove insoluble material. Chlorination and the use of charcoal were the other two processes expected. Common incorrect answers were desalination and distillation, which were appropriate for sea water but not river water.

CHEMISTRY

Paper 5070/31
Practical Test

Key messages

- Success in this paper required candidates to meet the practical and mathematical demands of a volumetric exercise.
- The examination's qualitative tasks involved test-tube observations, a gas identification and conclusions regarding the identity of the ions in unknown aqueous solutions.
- Candidates competent in volumetric calculations, following instructions involving test-tube reactions and in the accurate recording of their observations performed well.

General comments

Candidates capably carried out the titration involved in **Question 1**, although few successfully used the data generated in answering the related calculations.

While all the candidates attempted the tests in **Question 2**, there was variation in the standard and completeness of the observations recorded, especially where reactions were unfamiliar.

The number of scripts received in this series was small and therefore an extremely narrow range of different responses was seen.

Comments on specific questions

Question 1

(a) The results table was almost always completed properly. The majority of candidates produced concordant titres; there was some variation in their accuracy. Once two concordant titres are obtained, there is no benefit to be gained from performing additional titrations.

Some candidates attempted all the calculations that followed, although few performed well.

(b) This was calculated correctly by some and those candidates generally gave their answer to three significant figures.

(c) This question was correctly answered by a minority of candidates and many produced seemingly random incorrect working.

(d) This question was hardly ever correctly answered and many either produced incorrect working or did not attempt the question at all.

(e) This question was hardly ever correctly answered and many either produced random incorrect working or did not attempt the question at all.

(f) This was answered correctly by the majority of candidates. A few incorrectly either gave names or gave the formula of sodium sulfate as $NaSO_4$.

Question 2

Candidates should be encouraged to make full use of the Qualitative Analysis Notes supplied. There was much imprecision in the way candidates expressed the observations in two-stage tests involving the addition of firstly a few drops of reagent and then excess reagent. For example, the unqualified phrase 'soluble precipitate' is difficult to interpret in the context of a longer response.

(a) test **1**: This was generally well answered although candidates should be encouraged to allow precipitates to settle within a coloured solution such as **R** before attempting to identify their colour.

test **2**: The majority of candidates correctly observed a red-brown precipitate insoluble in excess NaOH.

test **3**: This unfamiliar reaction proved difficult to candidates to observe accurately.

test **4**: Many candidates made correct observations.

(b) This was answered well by those candidates who had made correct observations in test **2** and the majority did so.

(c) test **1**: This was poorly answered. Candidates should be encouraged to allow precipitates to settle within a coloured solution before attempting to identify their colour.

test **2**: This was poorly answered, with the colour of the precipitate often misidentified.

test **3**: This was more successfully answered. A green precipitate, soluble in excess NaOH was often stated, although the resulting green solution was less often mentioned. After warming, ammonia was often identified (perhaps by smell alone) without mentioning damp red litmus paper, for which no credit was available. In some cases, it was not clear whether the litmus was being used to test the gas or the solution in the boiling tube.

(d) Those who observed the green precipitate soluble in excess NaOH in test **3** usually identified chromium(III) as being present in **S** and were credited even if the observation in test **2** was incorrect or missing. The ammonium ion was often identified but could not be credited if ammonia was not named in test **3**. There was confusion between ammonia (gas) and ammonium (ions). The presence of sulfate ions in **S** was less often credited because of the failure to produce a valid observation in test **1**.

CHEMISTRY

Paper 5070/32
Practical Test

Key messages

- Success in this paper required candidates to meet the practical and mathematical demands of a volumetric exercise.
- The examination's qualitative tasks involved test-tube observations, a gas identification and conclusions regarding the identity of the ions in unknown aqueous solutions.
- Candidates competent in volumetric calculations, following instructions involving test-tube reactions and in the accurate recording of their observations performed well.

General comments

Candidates capably carried out the titration involved in **Question 1**, although few successfully used the data generated in answering the related calculations.

While all the candidates attempted the tests in **Question 2**, there was variation in the standard and completeness of the observations recorded, especially where reactions were unfamiliar.

The number of scripts received in this series was small and therefore an extremely narrow range of different responses was seen.

Comments on specific questions

Question 1

(a) The results table was almost always completed properly. The majority of candidates produced concordant titres; there was some variation in their accuracy. Once two concordant titres are obtained, there is no benefit to be gained from performing additional titrations.

Some candidates attempted all the calculations that followed, although few performed well.

(b) This was calculated correctly by some and those candidates generally gave their answer to three significant figures.

(c) This question was correctly answered by a minority of candidates and many produced seemingly random incorrect working.

(d) This question was hardly ever correctly answered and many either produced incorrect working or did not attempt the question at all.

(e) This question was hardly ever correctly answered and many either produced random incorrect working or did not attempt the question at all.

(f) This was answered correctly by the majority of candidates. A few incorrectly either gave names or gave the formula of sodium sulfate as $NaSO_4$.

Question 2

Candidates should be encouraged to make full use of the Qualitative Analysis Notes supplied. There was much imprecision in the way candidates expressed the observations in two-stage tests involving the addition of firstly a few drops of reagent and then excess reagent. For example, the unqualified phrase 'soluble precipitate' is difficult to interpret in the context of a longer response.

(a) test **1**: This was generally well answered although candidates should be encouraged to allow precipitates to settle within a coloured solution such as **R** before attempting to identify their colour.

test **2**: The majority of candidates correctly observed a red-brown precipitate insoluble in excess NaOH.

test **3**: This unfamiliar reaction proved difficult to candidates to observe accurately.

test **4**: Many candidates made correct observations.

(b) This was answered well by those candidates who had made correct observations in test **2** and the majority did so.

(c) test **1**: This was poorly answered. Candidates should be encouraged to allow precipitates to settle within a coloured solution before attempting to identify their colour.

test **2**: This was poorly answered, with the colour of the precipitate often misidentified.

test **3**: This was more successfully answered. A green precipitate, soluble in excess NaOH was often stated, although the resulting green solution was less often mentioned. After warming, ammonia was often identified (perhaps by smell alone) without mentioning damp red litmus paper, for which no credit was available. In some cases, it was not clear whether the litmus was being used to test the gas or the solution in the boiling tube.

(d) Those who observed the green precipitate soluble in excess NaOH in test **3** usually identified chromium(III) as being present in **S** and were credited even if the observation in test **2** was incorrect or missing. The ammonium ion was often identified but could not be credited if ammonia was not named in test **3**. There was confusion between ammonia (gas) and ammonium (ions). The presence of sulfate ions in **S** was less often credited because of the failure to produce a valid observation in test **1**.

CHEMISTRY

Paper 5070/41
Alternative to Practical

Key messages

- Some candidates found it difficult to apply knowledge in new contexts.

General comments

Candidates were able to make a good attempt at all the questions.

Comments on specific questions

Question 1

(a)–(c) Candidates generally found recognising key pieces of laboratory equipment and their function straightforward. Some candidates confused a burette and pipette. Other candidates chose the wrong type of flask or simply wrote 'flask' when the name; 'conical flask' was required.

(d) (i) Most candidates could label the axes but some did not include units.

(ii) Most candidates plotted points correctly. Some found the scale on the *y*-axis difficult.

(iii) A significant number of candidates found it difficult to draw a smooth curve to the points. Some joined the points in a series of straight lines; some had a very uneven curve and some incorrectly ignored the last point and made a curve through the rest.

(iv) Most could read a correct value from the graph based on their chosen curve.

Many extended their curve effectively. Some incorrectly made the curve go back on itself so that the temperature when the reaction took 180 s was greater than the temperature which took 150 s. Credit was given for correctly reading a value from an extended line even if the line was incorrect.

Few candidates realised that the problem with a higher temperature was that the time taken would be extremely short and therefore difficult to measure.

Question 2

(a) Many candidates drew and labelled a diagram effectively. Some did not indicate that filter paper was needed. Some did not label the black solid and colourless solution in the correct places.

(b) (i) Candidates found this question difficult. Many clearly found the concept of identifying different components in a mixture and the idea that each component will generally react independently difficult to grasp.

Many candidates described either the reactions of the carbonate with the acid or the reaction of barium chloride with the sulfate; few candidates described both sets of observations. A significant number of candidates thought that sulfur dioxide was formed from the sulfate.

Many candidates recognised that ammonia is given off and it is identified using red litmus paper turning blue.

Very few candidates realised that all these reactions were on the same mixture which they had been told contained carbonate and sulfate. As a result, the nitric acid would also react with the carbonate and produce effervescence of carbon dioxide here as well as in the barium chloride test. Most candidates recognised the yellow precipitate, but many described the ion as an iodine ion or simply iodine rather than iodide.

(ii) A number of candidates were able to suggest ammonium iodide even when they had not completed the results table correctly.

(c) Many candidates were able to conclude that the black solid contained copper ions or that the solution formed was copper sulfate. Fewer were able to take this forward to realise that a blue precipitate, which dissolves to form a darker blue solution, would be produced when the solution reacts with aqueous ammonia.

Question 3

Many candidates were less familiar with these organic reactions than they were with the inorganic reactions. Better performing candidates used the information in the introductory paragraphs to help them plan the tasks, even if they did not know all the expected outcomes. It is essential that candidates know how to use data and other information to plan experimental tasks. Answers showed that candidates did not read the contextual information that was given and did not use it to structure their answers. Many answers did not address all the points required in the question. Some candidates only tried to identify two of the substances and then said the third is known by default even though the question said, ‘Each liquid must be identified by a positive test.’

Many candidates did not describe any safety risk or precaution. Some of those who attempted to do this did not fully understand the difference between a risk and a precaution. Candidates were required to identify a safety risk or hazard which was specific to their experimental procedure and then describe how this risk could be reduced by taking a suitable precaution. Many simply suggested wearing goggles with no reference to why.

Question 4

(a) This question was generally well answered.

(b) Candidates found this question difficult. The most common error was for candidates to think it was related to dissolving of the solid. However, step **3** states that all the acid was previously dissolved. Some candidates were able to recognise that shaking the flask causes mixing, but few recognised the need for the concentration to be made equal throughout the flask.

(c) Some candidates wrote about the volume of sodium hydroxide rather than recognising the end point of the reaction.

(d)(e)(f) Many candidates were able to answer these correctly; some did not take note of the requirement in **(e)** for the answer to be given to three significant figures.

(g) This was answered correctly by most candidates.

(h) This question tested candidate’s understanding of concordance. It showed that many did not understand how to select appropriate titration values. Very few were able to explain why they had selected particular values with most making vague statements about the values being close together.

(i)(j)(k)(l) Many candidates found these calculations difficult.

(m)(i)(ii) Very few candidates were able to calculate this correctly even though they had been given a value to use for the concentration of the sodium hydroxide if they had been unable to complete the previous parts. It illustrates that candidates find it difficult to apply their knowledge in new contexts.

Most candidates knew the colour of iron(II) hydroxide although some confused it with iron(III) hydroxide.

Question 5

(a) Most candidates found this straight forward.

(b) A number of candidates suggested neutralisation but this was not acceptable as the question required them to use the information in the table to deduce that it was exothermic. Some candidates confused exothermic and endothermic.

(c) Few candidates were able to recognise that doubling the number of reacting particles by doubling the concentration would double the energy released and hence double the temperature rise. Some candidates were confused between energy change and rate of reaction.

(d)(i)(ii) The ideas of heat loss and insulation were well known.

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Paper 5070/42
Alternative to Practical

Key statements

- It is essential that candidates read the questions carefully. This may mean reading the question more than once. Errors in **Question 1 (c)(iii)**, **1 (c)(iv)**, **2(e)** and **3(a)(xi)** can, in many cases, be attributed to not reading the question carefully.

- Candidates should be aware that pipettes and burettes are accurate pieces of measuring apparatus. Pipettes are designed to deliver **one** volume accurately, whereas burettes can deliver anything in between 0.0 cm^3 and (usually) 50.0 cm^3. Measuring cylinders are much less accurate. Although some beakers have graduations on the side, the graduations are only useful to give very approximate indications of volume.

Comments on specific questions

Question 1

(a) This was answered well, although there were many incorrect spellings. 'Biuret' and 'biuerette' were seen regularly. A small number of candidates transposed burette and pipette. The conical flask was occasionally called a volumetric flask.

(b) (i) Candidates found this very challenging. Very few referred to H^+ despite the information in the equation. Some chose to focus on apparatus **C** rather than sulfuric acid. 'Catalyst' was seen occasionally.

(ii) Candidates found this very challenging. Many had the colour change the wrong way round. Presumably this was because the colour change from pink to colourless is what would be observed when using acidified potassium manganate(VII) to test for sulfur dioxide and other reducing agents.

(iii) This was answered extremely well. There were no common errors.

(iv) This was answered very well. There were no common errors.

(c) (i) 0.012 mol was a common answer from those who omitted to consider that 25.0 cm^3 was taken from a total volume of 250 cm^3 thus division by 10 was required.

(ii) This was answered quite well. There were no common errors.

(iii) This was answered quite well. Some used 24.7 cm^3 instead of 24.55 cm^3.

(iv) Candidates found this very challenging. Some divided by 158 instead of multiplying. Answers given to other than three significant figures were often seen, despite the requirement of the question. Candidates are advised to read the question carefully to avoid this kind of error.

Question 2

(a) (i) This was answered quite well. Many omitted the formation of a colourless solution. Ca^{2+} and Mg^{2+} were seen occasionally as conclusions.

(ii) This was answered well. The most common error was stating that the precipitate dissolved.

(iii) Candidates found this very challenging. Sulfur dioxide/SO_2 was rarely seen. Many other gases and non-gaseous substances were commonly given. SO_3^{2-}/sulfite ion was extremely rare.

(iv) This was answered quite well. Iodine was the most common incorrect answer.

(b) Some candidates incorrectly assumed that a solution was present at the start. Candidates who read the question carefully realised that they were provided with a mixture of solids

Despite being told that they were provided with a mixture two solids, many described methods of preparing the two solids individually.

The addition of water, without which the separation would be impossible, was often missing. Stirring or alternative methods of getting the sodium chloride to dissolve were also often missing.

Non-addition of water to the mixture of solids often meant that it seemed that two solids were being separated by filtration.

Purification of barium sulfate by washing and drying was also omitted regularly.

Better performing candidates tend to to write a rough plan before answering the question in full.

Question 3

(a) (i) This was answered well. Neutralisation and exothermic were seen commonly. In some cases, both were given. Redox was a common incorrect answer.

(ii) This was answered extremely well. Measuring cylinder was occasionally seen.

(iii) This was less well answered. Pipettes were commonly seen.

(iv) Heat loss was not commonly given as a reason for not using a glass beaker. Conical flasks and other pieces of glassware were common answers.

The heat evolved causing the glass to break was a common answer. The suggested improved was often to use Pyrex glass to withstand high temperatures. Metal beakers or crucible were also common suggestions.

Many gave the impression that they thought that the beaker was being used for measurement and was thus unsatisfactory.

(v) Points were plotted accurately and the lines were drawn extremely well.

(vi) The anomalous point was identified by many candidates. The most common error was to identify the first point as the anomalous point. A small number of candidates identified two ‘anomalous points’.

(vii) The correct ruled straight line was usually drawn.

(viii) The correct ruled straight line and the intersection were usually drawn. A small number of candidates drew either a curve or another straight line between the points instead of an intersection.

(ix) This was answered quite well. Some candidates used a scale other than 1 small square = 0.4 cm^3.

(x) The majority of candidates gave the temperature at the intersection as their answer without subtracting the original temperature.

(xi) This question was the most challenging on the paper for the vast majority of candidates. The answer to **(ix)** was often repeated, without the addition of 25.

(b) A variety answers, other than heat loss, were seen to this question.

Question 4

(a) This was answered very well. A small number reversed anode and cathode.

(b) (i) Many ions or species other than H^+ were seen on the left-hand side of the equation.

(ii) This was answered very well. Lighted splints relighting were seen very occasionally. Using a lighted splint for oxygen and a glowing splint for hydrogen were seen occasionally.

A burning splint blown out is different to a glowing splint.

Question 5

(a) This was answered extremely well. The full name of gas syringe instead of syringe (alone) was preferred.

(b) Better performing candidates stated that the gas would escape from the apparatus when replacing the bung. It was insufficient to say a gas was formed.

(c) (i) Candidates found that giving two names and two units was challenging. Units were often missing. Rate of reaction was commonly seen on either axis.

(ii) Although the question asks what the candidate **sees**, many answers gave statements other than observations. Some referred to two out of fizzing, bubbling and effervescence. Reference to a colour change to blue had to refer to the solution. Some described what they would see in the gas syringe.

(iii) Many answers stated that the rate of reaction increased, presumably due to confusion between rate and volume. Although gradient of the graph was rarely mentioned, those who did mention it often stated that gradient increased. This was presumably for similar reasons to those that thought that the rate increased.